IRON and STEEL IN BRITAIN
1870–1930

A comparative study of the causes which limited the Economic Development of the British Iron and Steel Industry between the years 1870 and 1930

by

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PREFACE

This study was commenced in 1931 but had to be put aside owing to the pressure of other work. At that time the main lines of treatment were due to a suggestion by Mr. J. W. T. Rowe of Cambridge University and formerly of the London School of Economics. The authors have obtained their facts from official sources in the five countries studied and from correspondence with some leaders of the industry and other individuals therein, from the trade journals and other works, and a lengthy list would be required to acknowledge all the sources consulted. Reference is, however, made at the beginning of the Appendix to the main sources of information. The authors appreciate that the statistics are not in some cases as complete as could be desired; but while the data can be added to on a future occasion, the primary object of the study has been to portray the general trend over a considerable period of years and not to make an exhaustive detailed treatment of each of the many phases of the iron and steel industry. It is hoped that the book will have a challenging effect. So much sheer nonsense has been talked or published by prominent men in the industry from the time of the great steel inventions to the present day that the question of responsibility for the relative decline of the British iron and steel industry ought to be threshed out. The authors interpret their study to the effect that some though not all of the causes of deterioration were within the powers of the industry to control and it did not. Greater vision on the part of the leaders, greater determination to anticipate the trend of the industry, a greater respect for science, the ability to think on national lines instead of parochially would at any time up to 1910, but preferably before 1900, have saved the industry some of the difficulties it confronted during and after the European War of 1914–18.

N.B.—References to "the war" in the text are to the war of 1914–18.

The thanks of the authors are due to Miss M. Lally, B.A., for assistance in proof reading.

T. H. B.
G. O. H.

FOREWORD

Although Mr. T. H. Burnham has insisted that my name appear on the title-page as co-author with him of this study, I wish it to be clear that the credit is really Mr. Burnham's and not mine. He it was who, as one engaged in the industry, collected and collated all the data on the technical aspects of the industry with which the study is mainly concerned. My share of the task has been to advise on the presentation of the material and to assist in the re-writing of the original study. I helped also to sketch in the background against which the industry was operating, and must therefore accept responsibility for much of Chapters I and II, in which broader economic aspects and the relations of the industry to the British and world economy are all too briefly discussed.

Tribute is also due to Mr. Burnham for his tireless energy in bringing this study to completion under exceptionally difficult conditions.

G. O. H.

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INTRODUCTION

(*a*) Object of the Study

The British iron and steel industry suffered a relative and in some respects, absolute decline over the period 1870 to 1930. This statement is not an assumption but is based on a review of the development of the industry as set out in Chapter I. This chapter shows strikingly that in tonnage output of both iron and steel the industry in Great Britain either advanced more slowly than in other countries, or actually declined while others continued to

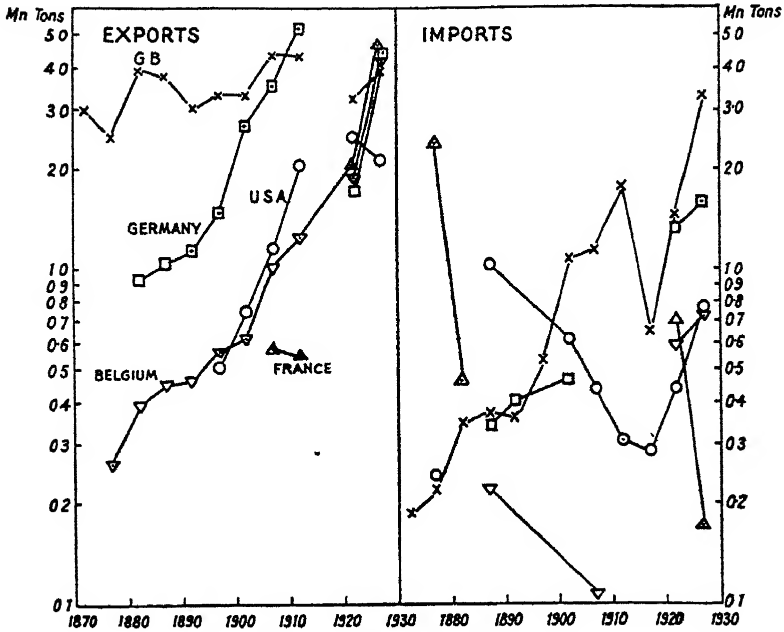

FIG. II (Ratio Scale)
IRON AND STEEL EXPORTS AND IMPORTS (TONNAGE)

advance (Fig. I); that British export trade suffered similarly (Fig. II); and that the loss in quantitative output was only compensated in part by a gain in qualitative output.

The picture thus presented provides the subject-matter of the enquiry. Its object is to identify the significant factors in the decline of the industry; to ascertain if this decline was natural or inevitable, that is, whether it was due to external factors beyond the control

of the industry itself, or due, on the other hand, to internal inefficiencies within its control, and if both external and internal factors were operative to assess their relative importance and to offer some conclusions.

It is proposed in a second study to analyse similarly the development of the industry subsequent to 1930. Perhaps the lessons that may be learned from the past will afford some guidance for the future organization and conduct of the industry.

(*b*) Importance and Complexity of the Industry.

To-day the country is at war. Tanks, guns, ships and bombs are the decisive weapons. These weapons are made of steel. The machines which make them are made of steel. In peacetime the development of railroads, motor transport, sea transport, depends on steel; the skeletons of great buildings, works, theatres, blocks of flats, are made of steel. Steel is used for razor blades, for cutlery, for transport vehicles, for the framework of office buildings and office furniture, for pots and pans and cooking stoves, for printing presses and cranes, for pen-nibs and the great masts of broadcasting stations, for pipelines and for bridges; steel is in fact the basis of mechanized civilization. Even in the present age of concrete, non-ferrous alloys and plastics, this remains true. Iron and steel statistics are commonly accepted as indices to economic progress; a generation ago this was still more true.

Both technically and economically the iron and steel industry remains one of the most important and the most complex of all industries; important because the tonnage produced is greater than that of all other metals put together, and complex because it is not one, but a congerie of trades. The technical set-up of the industry and the range of trades covered are shown in Fig. III.

(*c*) Plan of the Study

The study begins with a statistical and descriptive survey of the British industry at the beginning, middle and end of the period, in relation to the world development of the industry, particularly in Germany, France, Belgium and U.S.A., which, with Great Britain, accounted for 80 per cent of the world output. The basic matter is set out in Figs. I and II, which show the tonnage of the output and exports of the main producing countries, not only as absolute figures, but also relatively in order to show the *rate* at which developments were taking place in one country as compared with another. Conditions in the various countries, however, are not uniform.

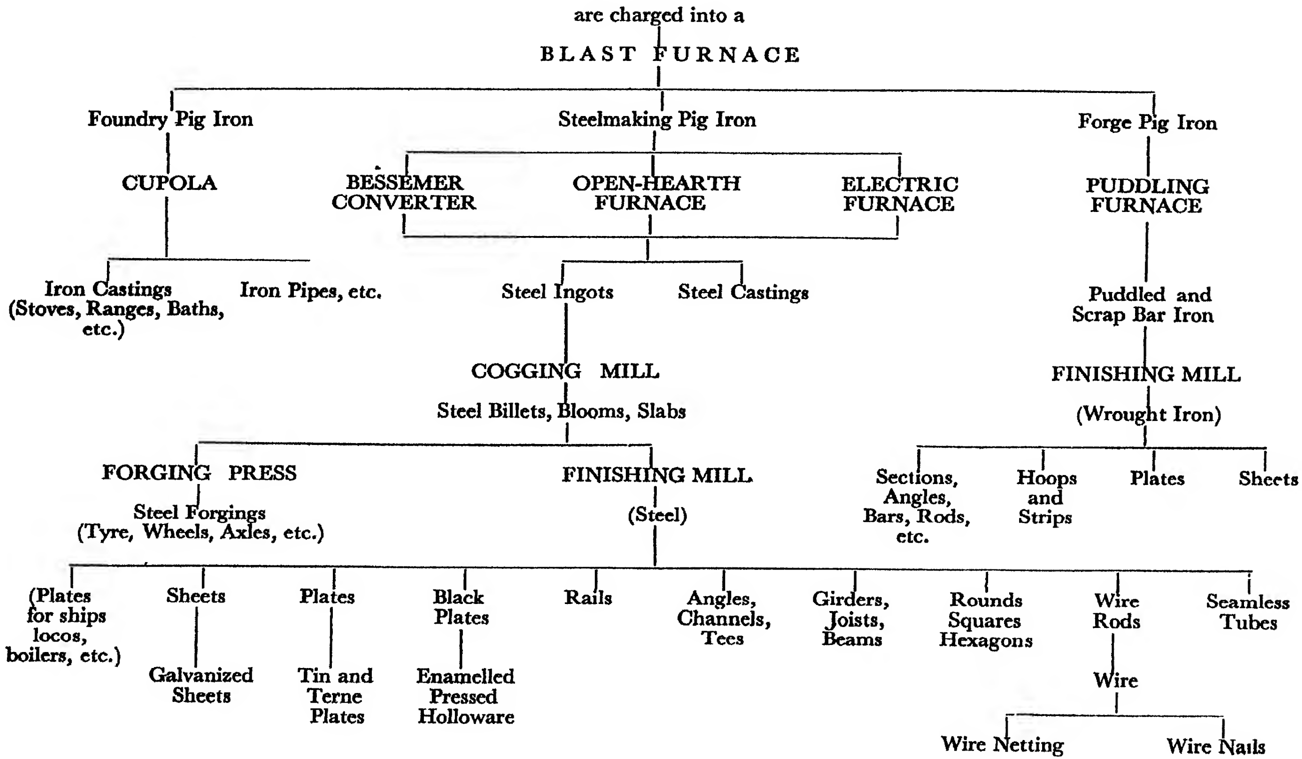

FIG. III

TECHNICAL SET-UP OF THE IRON AND STEEL INDUSTRY

(See "Notes on Technique of Iron and Steel Production," p. 21.)

Some countries have larger populations and larger home markets than others. Moreover, the conditions change; some countries develop later than others and rates of population growth may vary enormously. The output of the British industry is therefore examined in relation to the home market and home consumption. Since, however, sales may be made abroad as well as at home, movements in exports are then considered in relation to home and world demand. This analysis helps to give a more accurate picture of the development of the British industry in relation to that of other countries and indicates the importance of external factors in its development.

The next step is to examine briefly the relation between the development of the iron and steel and other British industries as shown by import and export statistics and the census of production.

The next two chapters investigate the natural, inevitable or unavoidable causes of the decline and the importance to be attached to each factor. The introduction to the influence of external factors given in Chapter I is carried further by the study of the economic environment. The iron and steel industry, as any other, does not operate in a vacuum, but in relation to industry and commerce as a whole. Factors of population, demand, price-levels, tariffs, all play their part. Chapter II therefore examines whether the history of the industry could have been otherwise in view of the general economic framework, national and international, in which it had to operate. It is found that the general factors were extremely important, but to complete the study of external causes Chapter III investigates whether there were any scarce factors in this country's natural resources, ores and coke, or transport. It is, however, found that the British industry did not appear handicapped in regard to either resources or assembly costs.

The economic environment and the raw materials position do not provide a complete explanation of the problem, and the next five chapters investigate the internal factors; in particular, whether there were inefficiencies in pig iron production (Chapter IV), wrought iron production (Chapter V), steel production (Chapter VI), capitalization (Chapter VII) and in the industry's organization, labour and management (Chapter VIII). The contribution of each factor to competitive weakness is discussed.

In Chapter IX the results of the investigation are summarized and an attempt made to value the relative importance of the external and internal factors contributing to the decline of the industry.

(*d*). Notes on the Technique of Iron and Steel Production

The following notes may assist the non-technical reader. They are intended merely to give a picture of the typical processes, and not as a technical disquisition on steel making.

Iron Ore is a natural mineral substance consisting of iron compounds with non-metallic elements as impurities (gangue). Iron ores may be classified in three ways, according to

(1) Chemical composition, e.g. oxide, carbonate.
(2) Phosphorus content: if not over 0·1 per cent, the ores are variously known as non-phosphoric Bessemer ore, hematite, etc. If over 0·1 per cent the ores may be termed phosphoric non-Bessemer ore, basic Bessemer ore, etc.
(3) Nature of the gangue, e.g. silicious ore, self-fluxing ore. The latter is an ore in which the proportions of lime, magnesia, alumina and silica are such that no addition of flux is needed for smelting.

The commercial ores include oxides and carbonates. The oxides are of three types: (1) anhydrous ferric oxide, ordinarily known as hematite or red hematite (Fe_2O_3); (2) hydrated ferric oxide, known amongst other names as brown hematite, limonite, etc. ($2Fe_2O_33H_2O$); (3) magnetic oxide known as magnetite (Fe_3O_4).

Carbonates are commonly known as spathic ore ($FeCO_3$), or black band (mixed with clay as clay ironstone). Ores are sometimes roasted to drive off water or to convert carbonate into oxide.

Coke is the residue obtained by driving off the volatile matter from coal. Metallurgical coke for steel making is made in either beehive or retort ovens; when the volatile matter is collected and utilized the oven is said to be a by-product oven. Furnace coke is used in smelting ores in blast furnaces. Foundry coke, which has a longer coking period than furnace coke, is used in cupolas for melting iron for casting.

Limestone (calcium carbonate) is a flux or material used in smelting for the purpose of combining with the gangue of the ore and producing a suitable slag by making it more fusible, or by combining with impurities and preventing them from entering the iron. Limestone is a basic flux, so are fluorspar, magnesia and dolomite, though the two latter are not much used. Acid flux is sand, though it is practically never used except to render less viscous a slag high in lime content.

A Blast Furnace is an iron or steel shaft or stack, usually about 70 to 100 ft. high, lined with refractory (fire-resisting) material,

and supplied with blast for producing pig iron by smelting iron ores (to reduce the oxide to metal). It is kept at a temperature of about 1,500° C. at the top to 700° C. at the bottom. The raw materials—ore, coke and limestone—are charged at the top through a cup and cone, the molten iron and superincumbent slag being collected at the bottom and tapped out at intervals. By feeding fresh materials the process is continuous until the furnace has to be relined.

Blast furnace gas is taken off at the top of the furnace through a large pipe (downcomer), passed through a gas cleaner and then into Cowper stoves used for preheating the blast. Hot blast was introduced by Nielsen in 1828.

The ratio of the ore to the total charge is known as the burden. The operation of tapping the iron is known as casting, the iron being led off to pig beds or a pig machine, or into ladles if the metal is to be used direct in the molten condition.

Pig Iron contains up to 4½ per cent carbon and usually 1 to 2 per ent of silicon, and may be classified according to the purpose for which it is intended:

(1) Foundry pig iron is intended for foundry work, i.e. casting.
(2) Forge pig iron is used for making wrought iron.
(3) Steel making pig iron is used for making steel by either the Bessemer or the open hearth process. Acid steel and basic steel may be made by either process.

Foundry Pig Iron is remelted in a cupola or shaft furnace to produce stings of all types, including cast-iron pipes.

Forge Pig Iron is used for making wrought iron by the puddling ocess.

Wrought Iron is produced by the process of puddling, which may described as the oxidation and removal of silicon, carbon, nganese and phosphorus from pig iron, the operation being ried out on the hearth of a reverberatory furnace. The final duct in a pasty state (since pure iron has a higher melting nt than crude pig) is mechanically mixed with a proportion of g, most of which is removed in subsequent stages of manufacture. e pasty balls are inserted in a rotary squeezer and a quantity the slag expelled. The rough bloom thus obtained is rolled in ghing rolls into a flat bar known as puddled bar. This is cut short lengths, a number piled together, reheated and rerolled, en more of the slag is expelled. The product is called wrought , which may be refined by further rerolling. Wrought iron is a

pure form of commercial iron. It is very tough, though containing slag streaks, and can be hammer- or forge-welded. It had a wide use before the large-scale production of steel, but to-day it is used chiefly by blacksmiths. Wrought iron is distinguished from steel principally by the fact that the former never becomes molten during manufacture, whereas steel is melted and cast and was, therefore, once known as ingot-iron.

Steel has been defined as that form of iron containing less than 2·2 per cent of carbon (usually the range is from 0·10 to 1·3 per cent), produced in a fluid condition and hence practically free from slag. It is produced by the crucible, the Bessemer and the open-hearth processes, and also in the electric furnace. Steel may be produced as castings, or as ingots, which are subsequently rolled or forged to the required shapes.

The Crucible Process.—In 1740 Benjamin Huntsman developed the first successful process for the fusion of steel on a commercial scale. Blister steel, made by packing wrought iron in charcoal and heating between 900° C. and 1,000° C., was broken into pieces and melted in crucibles having a charge of about 100 lb. weight in each. This process is now only used for the small scale production of special tool steels.

The Bessemer Process, sometimes called converting, consists in blowing air through molten pig iron contained in a suitable vessel (converter), whereby the impurities are oxidized and removed. Depending on the type of lining of the vessel there are two modifications:

(1) The acid Bessemer process (the original process—1856) by which the silicon, manganese and carbon, but not the phosphorus, are practically eliminated. This process is therefore only used for non-phosphoric ores.

(2) The basic Bessemer process (the Thomas or Thomas-Gilchrist process—1878) by which most of the phosphorus and part of the sulphur are removed in addition to the above-mentioned elements. To do this the furnace is lined with a "base," e.g. limestone, which absorbs the phosphorus and yields a basic slag.

The significance of the Bessemer process was that it enabled steel to be produced cheaply for the first time on a large scale. The significance of the Thomas-Gilchrist process was that it permitted the utilization of ores of relatively high phosphorus content and therefore released for exploitation the iron ore fields of Germany

(Lothringen) and America. It should be noted that the resources of phosphoric ores in the world are vastly greater than those of non-phosphoric or pure ores.

The Open-Hearth Process (1867). In this process oxidation and removal of the impurities is carried out by heating with producer gas or blast furnace gas a bath of iron lying on the hearth of a regenerative furnace, generally known as a Siemens furnace.

The charge may consist of (*a*) pig iron—either solid or molten (Siemens process); or (*b*) pig iron and scrap (Martin process).

There are two modifications as in the Bessemer process.

(1) Acid open-hearth process (original process).
(2) Basic open-hearth process.

The significance of the Siemens-Martin process is that it permits the large-scale production of high quality steel.

Electric Furnace Processes of steel melting are classified according to the type of furnace employed—the most commonly used being the arc furnace and the induction furnace. This process is growing in importance though largely confined to the Sheffield area.

Ingots refer to the form in which steel is cast for subsequent rolling or forging. They range from 100 lb. each to 100 tons or more in weight.

Rolling is the operation of reducing the section of iron or steel by passing it between revolving cylinders called rolls, which are housed in a suitable framework and driven by an engine or motor. The usual temperature of rolling steel is about 1,050–1,100° C. at the commencement and finishing at 850° C.

Rolling Mills may be classified according to the nature of their product.

(1) Semi-finishing or roughing or cogging mills, in which billets, blooms, slabs and steel bars are produced.
(2) Finishing mills which roll down slabs, billets or blooms into plates, shapes or bars.
(3) Cold finishing mills are utilized to give good finish and accurate thickness.

Wire drawing is performed on a draw-bench consisting of a draw-plate and a power reel for pulling the metal of reduced section through the draw-hole.

Forging originally referred to the operation of changing the shape of a piece of metal by blows with a hammer, but the squeezing action of a hydraulic press is also termed forging (pressure forging).

Development of the Industry, 1870–1930

(a) Statistical Study

(1) *Production*

The world production of pig iron, wrought iron and steel from 1870–1930 is given in Fig. IV and Tables 1, 2 and 3. In the frontispiece (Fig. I) the rate of growth of iron and steel production is indicated on a logarithmic scale.

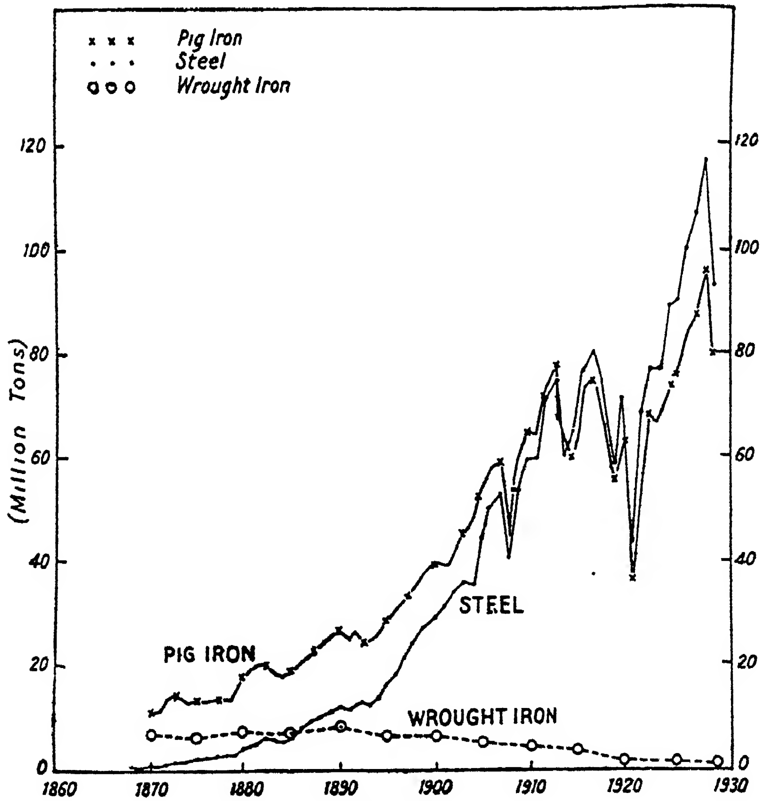

FIG. IV

WORLD PRODUCTION OF PIG IRON, WROUGHT IRON AND STEEL

In 1870 the world production of pig iron was nearly 12 million tons, that of wrought iron nearly 7 million tons. As steel making was a comparatively new process the total production was only about half a million tons.*

Wrought iron production increased slightly up to 1890, but after that date, as steel took its place, it continuously decreased, falling to about half a million tons in 1930. The production of pig iron and of steel, on the other hand, advanced rapidly from 1870 as technique improved and as industrialization spread.

Pig iron production is the basis of the iron and steel industry, and. its growth is an index to the development of that industry. By 1890 out put had reached nearly 27 million tons, and by 1913, 78 million tons. In 1929 a peak of 88 million tons was reached.

The world production of steel first exceeded that of wrought iron in 1886, but whilst it increased more rapidly than that of pig iron, on account of its advantages over the latter, it did not equal the world output of pig until 1914. After 1918 steel output leapt far ahead of iron output, since vast quantities of scrap were available. By 1929 the world output of steel attained a total of approximately 120 million tons, exceeding that of pig iron by about 20 million tons.

TABLE I

PIG IRON PRODUCTION (000 TONS), 1870–1930.

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1870	5,960	1,240	1,160	560	1,710	11,800
1875	6,370	1,730	1,420	530	2,020	13,600
1880	7,750	2,430	1,700	680	3,840	18,100
1885	7,420	3,220	1,600	700	4,040	19,300
1890	7,900	4,030	1,710	820	7,600	26,700
1895	7,700	4,690	1,970	820	9,450	28,500
1900	8,960	7,430	2,670	1,000	13,790	39,700
1905	9,610	9,350	3,020	1,290	22,990	52,700
1910	10,010	12,890	3,970	1,820	27,300	64,700
1913	10,260	16,490	5,120	2,450	30,970	77,900
1920	8,030	6,930	3,380	1,100	36,930	62,900
1925	6,260	10,010	8,360	2,500	31,410	75,690
1930	6,190	9,540	9,880	3,350	31,750	79,400

* The Bessemer process of steel making had been invented in 1856, but numerous difficulties, which at first threatened it with complete failure, had to be overcome before production could get into its stride. The first Siemens open hearth furnace was constructed in 1867, but in the succeeding three years was, of course, in its experimental stage.

TABLE 2

WROUGHT IRON PRODUCTION (000 TONS), 1870–1930.

Year	Great Britain Scrap, Ball and Bushelling Bars	Great Britain Puddled Iron	Germany	France	Belgium	U.S.A.	World
1870	—	2,610	890	640	480	1,160	6,970
1875	—	2,265	1,080	910	450	1,460	6,680
1880	—	2,010	1,120	1,025	490	2,125	7,670
1885	—	1,910	1,420	810	450	1,645	7,110
1890	—	1,930	1,480	860	550	2,590	8,560
1895	—	1,150	930	770	420	2,220	6,480
1900	—	1,160	950	720	365	2,225	6,760
1905	—	940	830	675	290	2,095	5,710
1910	—	1,120	350	530	160	1,780	4,710
1913	—	1,210	210	375	130	1,720	4,150
1920	387	590	85	45	20	1,420	2,310
1925	220	225	90	115	25	775	1,210
1930	156	113	20	100	—	—	—

TABLE 3

STEEL PRODUCTION (000 TONS), 1870–1930.

ear	Great Britain	Germany and Saar	France	Belgium	U.S.A.	World
870	220	130	80	—	40	510
875	710	320	210	50	380	1,790
880	1,290	690	380	130	1,250	4,180
885	1,890	1,200	550	150	1,710	6,190
890	3,580	2,100	670	220	4,280	12,280
895	3,260	3,830	860	450	6,110	16,650
900	4,900	6,360	1,540	630	10,190	27,830
905	5,810	9,510	2,220	1,180	20,020	44,220
910	6,370	12,890	3,360	1,910	26,090	59,330
913	7,660	17,320	4,610	2,430	31,300	75,230
920	9,070	8,400*	3,000	1,230	42,130	71,120
925	7,390	12,000*	7,300	2,370	45,390	89,080
1930	7,330	11,360*	9,300	3,420	40,700	93,330

* Germany only.

Tables 1, 2 & 3. Source: National Federation of Iron and Steel Manufacturers. See Appendix for annual figures (Tables 88, 89, 90).

The proportion of world output of pig iron, wrought iron and steel produced by this country is shown below:

TABLE 4

GREAT BRITAIN: PERCENTAGE OF WORLD PRODUCTION

Year	*Pig Iron*	*Wrought Iron*	*Steel*
1870	50	37·5	43
1880	42	26	31
1890	30	22·5	27
1900	23	17	18
1910	16·5	24	11
1920	13	25·5	12
1930	8	19	8

In 1870 Great Britain produced 50 per cent of the world's pig iron, 37·5 per cent of the wrought iron and 43 per cent of the steel. The percentages of iron and steel decreased steadily from that time to 8 per cent in 1930. On the other hand, in the declining wrought iron industry, where total output was steadily diminishing, Great Britain's output remained at 20 to 25 per cent from 1880 to 1930—over fifty years. The lingering strength in Britain of this decaying section of the industry is significant.

The rapidly falling percentage represented by Great Britain's output of iron and steel meant, of course, that the production in other countries was growing relatively faster. The chief of these was the U.S.A., where in 1870 pig iron production was the second largest in the world, i.e. 1·7 million tons or over one-quarter of this country's. Next came France, Germany and Belgium, though the two latter countries may be considered the birthplace of the industry. In wrought iron the U.S.A. also held second place with 1·15 million tons, or approaching half our production, and was followed by Germany, France and Belgium. The result of the Franco-Prussian war was to establish Germany's predominance over France in pig iron as well as wrought iron production.

The opening of the period may be taken to mark the beginning of the change over from wrought iron to steel, evidenced, for instance, by the switch from iron to steel rails between 1870 and 1880. By the end of this first decade steel production had increased eight times, and during the next decade the slope of the production curve for steel was twice as steep as that for pig iron. This was mainly due to the discovery of the basic process in 1878, a discovery which changed the face of the world as regards the relative importance of

the iron- and steel-producing areas. Western Europe was enabled to use her vast deposits of phosphoric ores and to become the second largest steel-producing area in the world, while the importance of the Lake Superior region was vastly increased.

The increase in steel production noted in 1880–90 was as rapid in this country as in any in the world, including the U.S.A., although it was mainly in acid steel. Although we had, and still have, ample resources of phosphoric ores, our resources of non-phosphoric ores on the north-west coast were limited, necessitating the increased import of pure ores from Spain and Sweden. After 1890, although production in U.S.A. and Germany began to increase at an even faster rate, mainly in basic steel, the upward trend of steel production in Great Britain definitely slowed down. Whatever the complexity of causes for this relative retrogression may be, it was undoubtedly the discovery and exploitation of the basic process which enabled Germany to eclipse us in production by the end of the century.

The U.S.A. exceeded our output of pig iron and steel by 1890, and by 1913 was producing about half the world output. Germany ranked second in importance as a competitor and surpassed Britain's output of steel in 1893 and of pig iron in 1905. By 1913 Germany produced 23 per cent of the world's steel and 21 per cent of the pig iron. In the decade before the outbreak of war in 1914 the rate of increase of pig iron production in France and Belgium was also greater than in this country.

Fig. I shows clearly that while from 1870 to 1913, and again from 1920 to 1930, U.S.A., Germany, France and Belgium experienced rapid and steady increases in output, Great Britain experienced in pig iron a very slow upward trend, in striking contrast to the other nations, and in steel the rate of development, which had kept pace with the other nations up to 1890, fell off gradually after that date.

In the last decade of the period Great Britain experienced a steep downward trend in both pig iron and steel, cutting across the general trend, and fell to the position of fourth country in order of importance as regards pig iron production and as regards steel output tied for third place with France.

(2) *Foreign Trade.*

The foreign trade of the five principal producing countries in the period under review is given in Fig. II and Tables 5 and 6.

FOREIGN TRADE

See Appendix for annual figures (Tables 92 and 93).

TABLE 5

EXPORTS (000 TONS APPROX.), 1870–1930.

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*Great Britain as per cent of the 5 countries*
1870	2,730	—	—	—	—	—
1880	3,650	750	100	300	150	—
1885	3,040	950	30	400	—	77 (1886)
1890	3,900	950	270	550	50	73·5
1895	2,800	1,500	—	500	120	64
1900	3,500	1,500	110	500	1,150	61
1905	3,800	3,360	600	920	1,050	39
1910	4,600	4,850	450	990	1,450	36
1913	4,980	6,200	540	1,550	2,800	30
1920	3,250	2,650	850	930	4,900	28·5
1925	3,750	3,200	3,960	3,150	1,750	22·5
1930	3,157	4,540	4,079	3,910	1,630	18·2

TABLE 6

IMPORTS (000 TONS APPROX.), 1870–1930.

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1870	156	700(?)	—	—	—
1880	348	400(?)	—	—	—
1885	346	—	—	—	—
1890	386	—	—	—	—
1895	406	350	—	—	—
1900	800	923	—	—	210
1905	1,356	215	—	—	—
1910	1,367	265	—	—	510
1913	2,230	304	630	888	·253
1920	1,107	1,200	884	852	420
1925	2,720	1,153	169	534	840
1930	2,908	1,140	479	677	629

(i) Exports: In 1870 the export tonnage of Great Britain in iron and steel was over three-quarters of the total export for the leading countries. Even at the end of the century the preponderating position of Great Britain was maintained, but her percentage of the total was falling off continuously and by the end of the period was only about 18 per cent.

The actual tonnage of British exports was not only maintained after the turn of the century, but was also considerably increased up to 1913. The rate of increase was, however, far greater in U.S.A., France, Belgium and particularly in Germany. In the latter country the rate of increase and the absolute figure leapt up phenomenally, and from 1910 to 1913 German iron and steel exports exceeded those of this country. In 1913 they amounted to 37 per cent of the total for the five countries. Between 1914 and 1920 the exports of the U.S.A. were, as would be expected, the largest, but this predominance was shortlived. In the last decade of the period British exports were exceeded first by France, then by Germany—which by 1930 was again ahead of France—and finally by Belgium.

(ii) Imports: On account of the variety of grades and forms of iron and steel all exporting countries have a certain import. In 1870 British imports amounted to no more than 150,000 tons. They increased slowly up to 1895 and then rapidly to over 2 million tons in 1913. They fell to a low level during the war of 1914–18, but increased phenomenally during 1920–30, attaining a maximum of 4½ million tons in 1927 comparing with a total steel output in that year of 7½ million tons.

In 1870–80 French imports were high (nearly 3 million tons in 1874) and imports into Germany and the U.S.A. were considerably higher than into this country. By 1895, however, British imports were the largest of the countries considered, indicating a tendency in the British trade to become a finishing and re-exporting industry. While German imports kept pace with ours till 1900, they subsequently fell off and in 1913 the order of importance for import tonnages was as follows: Great Britain, Belgium, Germany, U.S.A. and France. Between 1920 and 1930 German imports increased to a maximum of 2 million tons. Imports into U.S.A. also increased and were approximately the same as the Belgian imports (between ½ and 1 million tons per annum), while French imports remained the lowest.

The ratio of British imports to exports increased as follows:

IMPORTS AS PER CENT OF EXPORTS

1870	5½	1900	23	1913	45	1927	105
1880	9½	1905	36	1920	34	1929	65
1890	10	1910	30	1925	73	1930	92

SUMMARY

Over the sixty years 1870–1930 Britain's proportion of world output dropped from 50 per cent for iron and 43 per cent for the

infant steel industry to 8 per cent in each case. The last decade saw British *output* falling absolutely as well as relatively to that of the main competing countries.

	Pig Iron (million tons)		*Steel (million tons)*	
Annual Average	*Great Britain*	*Rest of World*	*Great Britain*	*Rest of World*
1870–74	6·38	7·02	0·44	0·34
1910–14	9·50	57·92	7·02	58·01
1915–19	8·33	55·49	8 94	62·43
1925–29	6·04	78·71	7·65	93·45

In 1870 British *exports* represented over four-fifths of the total for the main countries; sixty years later they were under one-fifth. The fall was not only relative but, towards the close of the period also absolute.

	Iron and Steel (thousand tons)	*(thousand tons)*
Annual Average	*Great Britain*	*Rest of World*
1905–09	437	638
1925–29	390	1,525

In 1870 British *imports* were negligible, but sixty years later Britain had become the world's chief importer, while in absolute terms imports were larger than they had ever been before and exceeded half the home production.

The position of Britain in the iron and steel industry had therefore changed over the period from one of unquestionable predominance to that of fourth both in production and exports. Over the last decade production was falling steadily, both absolutely and relatively, against the rising trend of world output, leading clearly to the conclusion that the British industry, certainly in a quantitative sense, was declining. It remains to be seen to what extent qualitative changes and changes in the type of product may modify the conclusion.

(*b*) An Extended Survey at the Beginning, Middle and End of the Period

(1) REVIEW OF POSITION IN 1870–80

In the decade 1870–80 Great Britain led the world in the production of pig iron and wrought iron. This country not only produced half of the world's pig iron and over one-third of the wrought iron,

but our exports were over three-quarters of the world's export trade, and they increased in absolute quantity and value during the decade. On the other hand, our imports, principally of Swedish bar iron, were relatively negligible—156,000 tons against a pig iron production of 6 million tons.

Great Britain was also the birthplace of the fundamental technical revolutions which ushered in the "steel age." In 1856 Bessemer had invented the converter process for making steel direct from pig iron, and this was followed by the Siemens-Martin open-hearth process. Numerous difficulties had, however, at first threatened the Bessemer process with failure and had to be overcome before large scale steel production could get into its stride.

The first Siemens open hearth furnace had been constructed in 1867, but in the three succeeding years the process was of course in its experimental stage. During the sixties, therefore, the output of steel remained small, and whilst in 1870 the British steel industry was carried on almost entirely in Sheffield and its neighbourhood, this year may be reasonably taken as the opening of the steel age. The pioneer work of Great Britain in steel production gave us an advantage over other countries which had later taken out Bessemer licences, and although Krupps constructed a Siemens-Martin furnace in 1870, i.e. three years after the first British furnace, Britain produced at the opening of this survey nearly half the world's output of steel.

Pig Iron.

In 1870 Great Britain produced four times as much as the U.S.A. which was followed by Germany, France and Belgium. Pig iron production depends basically on the raw materials—ore, fuel and limestone. In 1870 the British production of iron ore was over 50 per cent of the world's total, and the price per ton of iron content at least as low as in other countries. This, moreover, was in spite of royalty charges which, Sir Lowthian Bell (the most important man in the industry at the time) said, pressed heavily on the iron makers (British Association, 1876). We could use the hematites of the north-west coast, and imports of pure iron ore into Great Britain had only just started. Such imports were only 1 per cent of our consumption in 1870, but they could be cheaply brought to our blast furnaces at seaboard.

Germany was handicapped by a scarcity of non-phosphoric ores, the basic process not then being known, but in the U.S.A. the

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presence of hematite ores near Lake Superior enabled the rapid development of the production of irons suitable for Bessemer steel-making.

British coke at this period was known to be of high metallurgical quality, only the highest class seams of coal being used, and though it was all made in beehive ovens it was at least as cheap as any in Europe. At the end of the decade the development of chamber ovens on the Continent brought down the cost of German coke to about the same level, while coke at Connellsville ovens in the U.S.A. was definitely cheaper, although the freight to smelting centres probably doubled its cost on site.

It is doubtful, however, if full benefit was derived from the shortness of hauls in this country as even at that time the rail freight per ton mile was somewhat higher than in other countries. Output per blast furnace per year was, moreover, smaller than in Belgium and the U.S.A., while the price of limestone was shown by Sir Lowthian Bell to be rather higher than in Continental countries.

Great Britain's advantage lay in the easy local economy of production (although complaints were raised by the industry against high railway rates) and a favourable geographical position. On the whole, British pig iron was the cheapest in the world and this country was the only big exporter.

Wrought Iron.

When the period opens, at the dawn of the steel age, wrought iron was of considerable economic importance and Great Britain was the greatest producer in the world, with over one-third of the total output. The second place was held by the U.S.A. (with less than half our production), followed by Germany, France and Belgium. Our favourable position was connected with cheap forge pig iron, which formed the larger portion of our production, and the fact that production of wrought iron was more dependent on skill and experience than on plant (the output of puddling furnaces being limited to 5 cwt. at a time).

Capital was still being invested in puddling furnaces, forges and iron mills in this country, but during the decade under consideration the end was in sight of the struggle between wrought iron and the new steel industry. Between 1870 and 1880, for example, a complete change over from wrought iron to steel rails took place.

As regards prices, British unmarked bars were no higher than on the Continent, but the price of marked bars (constituting the

greater part of our production) was higher throughout the decade, so that we were selling on quality and exporting over 30 per cent of our output, a proportion which further increased as the decade advanced.

Steel.

Crucible steel had been made in this country since Huntsman's invention in 1740, but by 1860 the lead had been gained by Germany (Krupps). The steel-melting inventions in this country—the Bessemer converter and Siemens' open-hearth furnace—revolutionized, however, the annual rate of production and permitted a considerable reduction in price.

During the decade under consideration our steel production increased eight times, and from 1870 to 1886 Great Britain was the most important producer of steel in the world. This country in the course of its pioneer work substituted steel for iron for rails, sheets and tinplates. In the United States and Germany, however, steel production increased as rapidly as in this country and Germany and Belgium were entering the world export market; competition from the latter being already felt by our manufacturers.

During the next decade (1880–90) the rate of increase of world production of steel doubled. A second revolution in steel making had occurred in 1878, by the Thomas-Gilchrist discovery of the basic process of making steel from high phosphorus ores. From the point of view of fuel saving in the manufacture of steel, the invention of the basic-lined converter has never been equalled, and it made available a valuable by-product—basic slag, or phosphate of lime, used as a fertilizer. Its most valuable economic effect was, however, the release of phosphoric ores, in particular the Minette ores in Western Europe. By 1880, therefore, the stage was set for the passing of British predominance in steel making, at least so far as the exploitation of natural resources was concerned.

During 1880–90, as a result of the extraordinarily large and rapid increase in the world's demands for steel, production grew at an accelerated rate. It was as rapid in Britain as in any part of the world, but it was mainly of acid steel. Although the open-hearth process was developed more rapidly than the Bessemer process, as the former could be more accurately controlled, basic steel was prescribed for products subjected to shocks and strains. The British steel industry did not generally adopt the basic process, although our resources of non-phosphoric ores on the north-west coast were

limited. Instead it tended to move to the coastal districts where non-phosphoric ores for acid steel could be cheaply imported, rather than to those localities, such as Northants and Lincolnshire, where cheap native ores existed.

Foreign Trade.

In this decade Britain was the only large iron and steel exporting country and even in 1880 exported three times the totals of Germany, France, the U.S.A. and Belgium put together. The greater part of the British tonnage was pig iron—1 million tons per annum or more, and the largest portion went to Germany, which, the next country in order of importance, only exported about one-quarter of the British total.

Imports of iron and steel into Britain were small but showed a tendency to increase. Imports into France, Germany and the U.S.A. were very much larger, but varied considerably from year to year. There was a general fall over the decade of imports into France and Germany; those into the U.S.A. showed a maximum in 1880; Belgium, at this period, imported very little.

Prices.

Prices of pig iron were lower in Great Britain than in any other country, and whilst only limited data is available on the prices of steel products at this time, there is some evidence that our cost of steel production was below Continental costs. In particular, British prices were lowest for boiler plates, ship plates, merchants' bars, and rails, and in the exports of the latter we had practically a monopoly. In the early seventies, in fact, prices in England determined world prices.

Wages.

In 1870–80 wages in Britain were higher than on the Continent, both in pig iron and steel production. The fact that they were not a burden was associated with larger production than in other countries (thus giving lower overheads), and our greater experience and better technique. Sir Lowthian Bell expressed concern over the wages paid in Belgium and France, where they were 20 to 30 per cent lower than in corresponding jobs here. Even in the wrought iron industry it was appreciated that we could only continue to pay the higher wages if in possession of better plant. It was known

that the labour cost for rails was lower in Germany than here and Bell stated it was due to lower German wages. On the whole, however, though British wages were higher, labour costs were lower than in other countries.

Hours of labour were uncontrolled in Britain as well as on the Continent and in the U.S.A., and probably introduced no differential factor.

Plant.

The type of plant used at the beginning of the period was of course different from that in modern iron and steel works, and the cost per ton of furnace and mill capacity probably only one-half or even less than that of corresponding plant in 1930. Capital charges in Britain were relatively low, and although the newer plants abroad were of greater capacity, the capital charges were higher.

Organization.

The British industry had developed its organization at a time when it was essentially an iron industry. In iron a strong position had been built up under a regime of sturdy individualistic efforts by our producers; planned development was practically unknown and these characteristics tended to be impressed on the new steel industry.

The bulk production of steel was most economically carried out in association with iron smelting and a tendency arose to integrate the two processes. Further integration, backwards to mines and coke ovens, and forwards to rolling and finishing mills (see Fig. III), was a natural corollary, but this development occurred more rapidly in newly industrialized countries like Germany and the U.S.A.

Combinations in the British iron and steel industry were rare and transitory and not so developed as on the Continent. The British Iron Trade Association was, however, formed in 1876. There are a number of reasons why associations were formed earlier on the Continent, but one was the strength of British competition. Another defensive action of iron and steel industries abroad was high tariff protection as in France and the U.S.A. The German tariff was increased in 1878 and even in Belgium the tariff was higher in this decade than subsequently.

Summary

The general position outlined in 1870–80 indicates a strong and developing British iron and steel industry—the largest and most important in the world, and the birthplace of all the major inventions from those of Cort's rolling mill and Nielsen's hot blast stove to those of Bessemer, Siemens and Thomas. Britain enjoyed, too, at this time, certain other differential advantages—rich deposits of hematite ore in proximity to coal and to seaboard, a favourable geographical position and short hauls. Signs were not, however, lacking that pre-eminence was passing and relative decline inevitable. Prior to 1870 complaints were made that British wrought iron makers were not as skilled in the production of rolled iron as some Continental manufacturers. Practice in pig iron making was stationary, whilst innovations were being made in the U.S.A. and Germany, e.g. bigger units of plant, mechanical handling and intermediate ladles (mixers).

In the mass production of steel, foreign contributions were noteworthy, including duplicate converter bottoms, three-high rolling mills and continuous heating furnaces. The open-hearth furnace was first developed to a practical success in France, as was also the manufacture of ferro-manganese (which gives a cleaner and tougher steel), and the production of sound steel castings (free from blowholes and inclusions).

Foreign iron and steel industries appeared more progressive than the British, which failed to appreciate advances or showed inability to use them; it placed reliance on superior resources and was more inclined to apply capital to extensions rather than radical changes and advances. Plant layout was bad in many cases and, whilst it was already known that surplus blast furnace gases would provide all the heat required in a steel works, British works were not contiguous. Technical education was neglected not only for employees but for employers. It was not surprising, therefore, that leadership in technology and commercial application was passing abroad and, in fact, one of the reasons for the foundation of the Iron and Steel Institute in 1869 was that, owing to lack of technical training in this country, firms had to go abroad for managers.

At the end of the seventies relative cost advantages were definitely favouring the Continent, on the one hand from progressive scarcity of British high-grade ores, and on the other hand since abroad there was more efficient coke making, use of waste heat, technical follow-up of original inventions, layout of plant and standardization.

THE TREND BETWEEN 1880 AND 1903

The period 1880–1900 was characterized by a rapid—nearly sevenfold—increase in world output of steel due to the exploitation of the new mass-production processes. Pig iron production only slightly more than doubled in the same interval.

British pig iron output rose less rapidly than American and German. The U.S.A. had surpassed our total and Germany had nearly caught up, although by 1903 there were approximately the same number of furnaces in blast in each country. Pig iron prices in Europe rose from 1884 onwards, but in the U.S.A. they continued to fall until 1897. Continental prices during the period fell to the British level for some grades. British exports were, however, maintained, although imports increased, due to Britain continuing to specialize on hematite and forge and foundry pig, whereas basic iron was the principal Continental type.

In 1880 wrought iron production in the U.S.A. had caught up the British output and Germany was over one-half of ours; by 1900 the American output was twice the British, and the German output nearly as much as ours. The British figure had, in fact, fallen to less than 20 per cent of the world total.

In steel output also Britain was outpaced; by 1900 the U.S.A. produced twice as much and Germany rather more than Great Britain. By far the greater proportion of British steel was made in open-hearth furnaces and nearly all was of acid type, whereas the output of steel on the Continent was mainly basic in type, the largest constituent being Thomas steel. British export trade in iron and steel still amounted to half the world total, consisting mainly of finished products, such as rails, tinplate and galvanized sheets. The exports of Germany, Belgium and the U.S.A. were, however, increasing at a faster rate than British exports. Those from the Continent were mainly merchant-iron and steel bars while from the U.S.A. rails were the principal item.

British imports were increasing rapidly. Between 1880 and 1900 they trebled in total value but decreased in unit value, indicating a tendency to import materials in a less finished stage of production.

Most steel works in Britain had been established before 1880, and in 1900 there were no complete technically integrated plants; in particular, re-rolling in Britain was a separate trade. Abroad plants had been constructed in larger units or had been economically combined.

Organization of the iron and steel industry had developed faster in other countries than in Britain. Cartels were already highly developed in Germany and vertical concentrations in the U.S.A. Not only were horizontal and vertical combinations less highly developed in this country, but the role of merchants in sales organization was of greater importance. Price agreements in Britain were a well-established feature, but associations were informal and immature.

(2) REVIEW OF POSITION IN 1903–1913

Pig Iron.

Between 1903 and 1913 world production of pig iron rose from 45 to 78 million tons and British production from 9 to 10·3 million tons. Britain's percentage of world production, which had been 42 in 1880, fell, therefore, from 20 to 13. The U.S.A. was by far the greatest producer in the world and from 1906 Germany also surpassed Britain in output. It may be noted also that in this decade the rate of increase of production in France and Belgium was greater than in Britain.

In spite of the upward trend of pig iron prices from 1886 British pig iron remained at least as low as any corresponding European iron, except for basic iron, which was produced more cheaply in Lorraine and Luxemburg. American pig iron prices had trended downwards, and at the close of this decade dropped below Continental prices (e.g. Foundry II).

Production in this country might aptly be termed specialized and we continued to export forge and foundry and hematite iron to the Continent. The manufacture of these "special" irons was based on imported ores which continued to increase relatively to home ore production. A large percentage of the coke used was still made in old-fashioned beehives, although the change-over to chamber ovens had been practically completed on the Continent. The price of metallurgical coke had, in fact, fallen below the British price in one or two countries. Moreover, the size of British blast furnaces was now on the average below that of the four countries with which comparison is made, and the throughput per furnace was also the smallest.

It will be seen, therefore, that factors had intervened which were disadvantageous to the mass production of cheap pig iron in Britain. Nevertheless, international price comparisons indicate that this

country was apparently holding its own in regard to the price at which pig iron was put down at seaboard, and British exports were still the largest in the world, although now closely followed by German exports.

Wrought Iron.

Whilst steel had replaced wrought iron for most purposes by 1890 British production of puddled iron was nearly 1 million tons in 1903, about one-quarter of the world's total. Production in Britain actually increased up to 1913, both absolutely and relatively to the world total.

During this period Continental prices (particularly French) for unmarked bars were below British prices.

Steel.

World production of steel rose from 35 million tons in 1903 to 75 million tons in 1913. In that period British production rose from 4·9 to 7·6 million tons, so that our percentage of world production, which had been 31 in 1880, fell from 14 to 10. Whilst the U.S.A. and Germany were throughout this decade larger producers of steel than Britain, the rate of increase of steel production in Britain was also exceeded by that in Belgium and France.

The divergent courses of the British and foreign industries may be noted. At the end of the seventies very little basic steel was made—world production being not more than a few hundred thousand tons annually. In 1903, however, basic steel constituted 90 per cent of German output, 60 per cent of French output and over 50 per cent in the U.S.A., compared with only 20 per cent in this country. In this decade (1903–13) world production of basic steel nearly trebled, and in 1913 steel production in the U.S.A. and Germany was two-thirds basic steel, though production in Britain was still mostly acid open-hearth. Apart from the lag in the production of basic open-hearth steel in Britain, the complete neglect of the Thomas process from cheap home ores is to be noted, as, in spite of the well-known difference in quality compared with open-hearth steel, the bulk of the increase in Continental steel was of Thomas steel. The technical aspects of the subject cannot be discussed at this stage, but it provides an explanation of the somewhat higher costs of production of ordinary steel in this country.

The increase in British output was mainly in galvanized sheets and tinplates, ship-plates, sheets for the electrical and automobile

industries, armaments, mining and other specialities. Further progress is to be noted towards the industry here becoming a finishing industry and making specialities of high unit value.

Foreign Trade.

At the beginning of this period world markets in iron and steel were virtually supplied by three countries, Britain, Germany and the U.S.A. Between 1903 and 1913 British exports continued to increase, but during this period Germany took the lead as an exporting country. After 1910 the exports from the U.S.A. increased very rapidly, though they did not attain the British figure. Belgian exports increased at a rate equal at least to that of British exports, but French exports remained approximately constant. Britain was exporting over 10 per cent of her production of pig iron, but the increase in exports was mainly in galvanized sheets and tinplates. Whilst on the whole Britain exported about 35 per cent of the finished iron and steel she produced, in the two items mentioned she was exporting considerably more than she consumed in the home market and the value per ton of British exports was increasing and higher than that of Continental exports.

In 1904 Jeans pointed out that countries engaged in the export of iron and steel were also large importers. Between 1903 and 1913 British imports practically doubled, being at least twice those of any of the other countries considered. Expressed as a percentage of production, however, the British imports were closely followed by the Belgian: the latter and American imports increased till just before the European War, but German and French imports fell off. At the time it was commented that discriminatory prices on the Continent were reducing the consumption of certain descriptions of British iron and steel in domestic and colonial markets.

British imports were principally semi-finished steel products—blooms, billets and bars—from the Continent, and it is clear that the main development, so far as this country is concerned, was to concentrate on quality in default of maintaining and developing quantity of output.

Plant.

By this time a lag in growth of large scale production was noticeable in Britain compared with the leading competitive countries. For example, in 1900 there were ten firms in Germany with a capacity of over 300,000 tons per annum and only one in Britain. At the

same time some mills in the U.S.A. had outputs three times those in Britain but with less men. The necessity for the adoption of labour-saving devices in Great Britain was of course as great as in the U.S.A., Germany and Belgium, but the rate of modernization was slower, e.g. in mechanical handling and charging, the use of blast furnace, gas and hot metal mixers, electrification and the gas engine. In 1900 iron and steel sections were not standardized in Britain, although this had occurred in Germany in 1883, Belgium 1885, France 1896 and the U.S.A. 1898. Extreme subdivision of production continued in British iron works, cokeries and steel plants not being integrated. British plant was too durable, obsolete though not worn out, general and adaptable but not specialized.

Organization.

In the larger scale plants abroad the high capital charges necessitated continuous operation and were an important factor in the increased export drive in Belgium and Germany. These capital charges per ton were said to be only a few pence above the British, and could not, indeed, have been much higher than in Britain or were offset by the lower wages cost per ton, as there was felt to be no need to maintain the existing level of tariffs abroad. In fact, at this time there was a continuous decline in the protection of foreign iron and steel industries except in France. The U.S.A. was mainly concerned with supplying its own markets but was also beginning to compete seriously in world markets.

In addition to the greater concentration of production abroad, organization of the industry had rapidly been carried to greater lengths. Associations had developed on the Continent, not only in production but in transport and selling. In Britain there was a large number of firms and control was individualistic; such associations as occurred were transitory and organized efforts by the industry were non-existent or extremely limited.

Steel Prices.

For several years before 1914 the price of British steel billets did not differ appreciably from the home prices in the countries compared, though there is some evidence that Germany underquoted this country in foreign markets. As regards rolled products, British prices for joists, girders and merchant bars were on the whole above Continental prices. German prices for rails were above British prices up to 1900 but lower after that date. The position with

regard to thick plates is rather elusive, as whilst British ship-plate prices were the same as foreign plates, some grades of plates were dearer than German or even American home prices. For thin sheets, galvanized or tinned, British prices were definitely lower than foreign, and our lead in these highly finished forms of steel had been maintained. Apart from the highly finished forms, however, British prices tended, on the whole, to be rather above those of her competitors. The position, therefore, had changed from that ruling in 1870–80 and exports now depended essentially on quality.

Production Costs.

As regards production costs, wages paid on the Continent were lower than in Britain. Between 1903 and 1913 British wages were about 10 per cent above corresponding Westphalian wages and 20 per cent above those paid in Lorraine and the Saar. Wages are, of course, no criterion of labour cost, which depends largely on mechanization; this was apparent from American competition at a time when the wage level was considerably higher than here. Further, there is reason to believe that in the more technically integrated plants on the Continent, the gross productivity per man was higher than in Britain. Here again the situation had changed from that ruling thirty years previously.

Profits.

In so far as dividends are an index to the prosperity of the industry, there were indications in this decade that the profit-earning capacity of plants in Germany and the U.S.A. was higher than in this country. The dividends of the United States Steel Corporation were, however, moderate, due to over-capitalization and expenditure on the purchase of complementary plants, but the true return on the original capital was high.

Although some firms in Britain were paying good dividends they were mainly in special branches of the industry, e.g. armaments and shipbuilding. For the British industry in general there is reason to believe that the high costs of operation of small or obsolete plants prevented the accumulation of funds for replacements and modernization.

Summary.

Over the period 1903–13 the British differential advantages noted in the seventies had waned and foreign iron and steel industries were

gaining in momentum, particularly in regard to the production of semi-finished steel.

There was, of course, no reason to expect that the initial technical advantage of Britain would be permanent. Britain's blast furnaces were, by this time, smaller than those of her competitors and we had lost the lead in all mass-production lines. While during this decade, world production of basic steel nearly trebled, the increase was barely 50 per cent in this country, for we had failed to make a success of the Thomas process compared with the advances made in Belgium and Germany. There was, however, a change in the relative importance of producing districts in Britain, the growth being greatest in those where basic steel was made, i.e. a slow migration to the East Midland ores, but it required the impact of the world war of 1914–18 to force at last acceptance of the basic process in Britain.

THE WAR PERIOD

During the war from 1914 to 1918 the world production of pig iron fell from 78 to 65 million tons per annum and this was characteristic of all countries, except the U.S.A., where production rose from 23·3 to 44 million tons per annum. World output of steel increased from 75 to 86 million tons per annum, due principally to an increase of 50 per cent in the U.S.A. British production increased, but output in France and Belgium was reduced to very small proportions and even that in Germany remained stationary. It will be noted that during the war the world production of steel surpassed, for the first time, that of pig iron. This was due to an increase in the use of scrap for steel making and a fall in the demand for pig iron for making wrought iron.

Steel capacity in the U.S.A. increased considerably and in Britain appreciably, attaining in the latter 12 million tons per annum. An increase in capacity was also recorded in Italy, Canada, India, Australia and Japan, which was bound to have an effect in the post-war period. The bulk of the world production at this time was basic steel and in Britain the Ministry of Munitions worked hard to expand the scope of the basic process. Although steel output increased mainly in Scotland and Sheffield, there was a growing recognition of Lincolnshire and Northampton as low cost centres.

(3) REVIEW OF THE POSITION IN 1920–30

Pig Iron and Steel after the War.

The war left the world with increased capacity and after the short boom culminating in 1920, due to the anticipated demand for steel to make good the shortage for peace-time purposes, demand in Europe almost collapsed in 1921 and the slump was one of the severest on record.

After 1921, however, world production of pig iron increased again until it attained the pre-war rate. The increase occurred not only in the U.S.A. but on the Continent, and Germany and France exceeded British production, this being a new feature in the case of France. In Britain pig iron production was practically stationary, and the demand for forge and foundry iron and acid pig diminished. World demand was being deflected to different classes of iron and steel from those in which Britain had specialized.

World production of steel increased at a faster rate than before the war, attaining a total of 97·3 million tons in 1929. The war had not increased costs in the U.S.A. as much as in Britain, and American production increased steadily to attain 47·5 per cent of world production in 1929. After recovering from the war dislocation, Germany and France surpassed Britain in production. By the end of the decade Belgium attained double her pre-war output, although still remaining the smallest of the five producers. Britain alone did not share in the general advance, her steel production showing a tendency to fall. In the European re-distribution it should be noted that the productive capacity of Germany was reduced by the loss of the Lorraine orefield, which modified the internal economics of the industry, making it dependent on imports of ores from Scandinavia and Spain. The situation was eased by the use of large quantities of scrap in the Siemens-Martin process and strenuous efforts were made to modernize and rationalize German plants.

France and Belgium emerged from the war with strengthened competitive power; the former had increased her natural resources and expanded her output in reconstructed plants far beyond her own consumption, the latter practically rebuilt her industry from reparation payments. Reparations forced the Ruhr to expand its output and its plant, while at the same time setting up new capacity in Belgium and France.

Foreign Trade.

In 1920 the export trade of the U.S.A. was the greatest in the world, but from 1922 to 1924 Britain regained her premier position. Following reconstruction on the Continent between 1926 and 1930, however, first France then Germany and finally Belgium surpassed our total.

The chief component of British iron and steel exports was galvanized sheets, then came tinplates, and then thin sheets. The Empire had become our chief market. While the total value trended upwards, the average value per ton was, however, no higher than for the U.S.A. and Germany. British exports of machinery continued to increase, but so also did those from the U.S.A. and Germany; and each of these countries exported more metal-working machinery than Britain. Other countries were, in fact, tending to increase their capacity of finished steel, encroaching on Britain's last stronghold of pre-eminence.

During the decade British imports increased rapidly, attaining a maximum of over 4 million tons in 1927, so that British net exports tended to be the lowest of the five countries compared. There were actually net imports in 1926 and 1927. The increase in imports was mainly in blooms and billets, sheets and tin-plate bars. Imports of bars, angles and shapes, thick plates, hoops and strips, also increased. The semi-products came mainly from France, but Germany and Belgium also contributed an important quota. The primary branches of British industry were thus most affected by imports and it was obvious that great adjustments were necessary.

Britain was faced with the syndication of the German industry, which had power to exercise price differentials in export markets, and the increased necessity of the reconstructed French and Belgian industries to export. As a result iron and steel prices fell below the general commodity price level.

At the same time iron and steel industries appeared in lands hitherto comparative non-producers, e.g. Japan and Australia. This diminished the possibility of exporting pig iron and semi-finished products. The losses in exports of pig iron were not balanced by gains in other products, though Britain specialized in higher products, and our chief exports, viz. special sheets, were produced from imported basic sheet-bars.

Organization.

In this period there was a tendency in Britain towards vertical integration and in 1930 75 per cent of pig iron and 70 per cent of blooms, billets and slabs were consumed by the firms making them. On the whole, however, few large integrated concerns existed amongst many small undertakings which did not change with changing conditions governing location and the technical optimum of capacity.

Attempts to organize the industry were regional rather than national and associations were impermanent due to the depression. Organization was much more highly developed on the Continent, and although the rebate system was revived in Britain and the British Steel Export Association established, this country was particularly weak in export organization.

Prices.

During this decade prices fell in all countries, at first steeply, then more slowly.

Pig iron fell in Britain to a level below the home prices for corresponding irons in the U.S.A. and Germany, but was appreciably above the prices ruling in France and Belgium. It may be noted that the price of blast furnace coke and the price of native ore compared favourably with Continental prices, and the cost of assembly of raw materials per ton of pig iron was lower in Britain.

The price of British wrought iron bars was above French and Belgian prices and our imports increased from 15 per cent of our production in 1913 to over 50 per cent in the post-war years.

The price of steel billets was appreciably higher in Britain than were home prices on the Continent. It was the same for girders and joists, rails, merchant bars and plates, and thick sheets. It is possible, however, to divide the five countries into two price groups: (1) high priced, the U.S.A., Britain and Germany, (2) low priced, Belgium and France. As the degree of elaboration of steel products increased, the two price levels drew nearer together. In galvanized sheets, British prices were below Continental figures, and British prices for tin-plates were below American and German figures. British superiority was, therefore, being maintained in these specialized categories.

Continental export prices were discriminatory and the export prices of semi-steel products from Belgium and France were approximately one-half of home prices. German export prices were lower than British prices after 1923.

Production Costs.

There were several reasons why British costs at this time were relatively high. The average cost of iron ore charged to the furnaces was higher than on the Continent and little use was made of the cheap native ores. Coal prices rose more than steel prices and whilst they also rose abroad, greater attention was given on the Continent to fuel economy.

In 1920 most firms were overcapitalized and capital charges were high. The return to the gold standard in 1925, with its forcing down of the general price level, further augmented the load of interest on loans and debentures. Social service charges were also high, though this also applied on the Continent, and on the other hand British firms benefited from the Derating Act.

British wages continued to be higher than those paid in Germany, and much higher than in France and Belgium. The disparity had not increased compared with 1913, but British real wages were lower after the war. Hours of labour were reduced, but they were also lower on the Continent, although the eight-hour day was a disadvantage due to the higher wage level in Britain.

Plant in Britain was only partially employed, the following indicating the ratio of production to capacity in 1925:

	Pig Iron *per cent.*	*Steel* *per cent.*
Britain	44·5	58
Germany	59·5	84
France	68	78
Belgium–Luxembourg	75	78
U.S.A.	79	82

The fundamental fault with the British industry was its relatively low gross productivity per man which, coupled with the high capital and social charges and higher wages than on the Continent, prevented adequate allowance for reconstruction and modernization. Europe was more favourably situated for plant modernization and in America millions of dollars were spent during the decade on the improvement of steel plants.

Dividend-Earning Capacity.

In this decade, profits in the British iron and steel industry were non-existent, except in specialities and highly finished products (see Appendix). Firms representing 40 per cent of the industry paid no ordinary dividend from 1921 to 1929, the position being much worse

than in the countries with which a comparison is being made. Many of the French iron and steel firms earned substantial net profits, in addition to making adequate provision for amortization. There were, however, some lean years on the Continent, and in Belgium, for example, profit margins were narrow. In Germany, whilst dividends were lower than in the pre-war period, the average for the leading steel companies was from 5 to 6 per cent after 1925. In America dividends were at about the same level from 1924, except for the prosperous year of 1929. The dividends paid by the U.S. Steel Corporation were, however, still below those of the average company, although, as pointed out previously, this was no indication of true earning capacity.

In Britain the value of ordinary shares fell considerably and the iron and steel trade became discredited as a field for investment of capital. The last eight or nine years of the decade were, in Britain, a period of depression in contradistinction to the revival abroad after 1923. Some works were idle, others dismantled, and many firms had to undergo financial reconstruction. In 1930 there was still a wide margin between actual and nominal share values and a drastic reduction of nominal capital was required.

The immediate post-war period had been a time of prosperity, but instead of taking advantage of this to strengthen the industry, reserves were capitalized, bonus shares issued and capital liabilities fixed at levels in excess of the normal earning capacity of the plants. This watering of capital proved a fearful handicap to the industry in attracting new investment, although this was essential if pace were to be kept with developments in other countries.

On the Continent, reconstruction and re-equipment were financed by the State and the devastated districts were restored with modern plant of increased efficiency. In Britain, however, the pre-war plants, already old-fashioned, had not been destroyed. The layout of steel works was acknowledged to be poor, but modernization was not carried out and the pre-war gap between Continental and British technique persisted. This country was behind the Continent in fuel economy and mechanical handling equipment. There was a lack of high capacity semi-product mills and continuous strip mills, and the industry had tended to deteriorate to a jobbing trade working on imported semi-products. In this respect the post-war situation was an exaggeration of that before the war with semis now coming from France due to the transference of Lorraine. The continued general sterility in Bessemer practice made the establish-

ment of the Corby works by Stewarts and Lloyds the greatest post-war enterprise in British steel making.

The position of Britain was, however, made more difficult by two factors over which the industry had no control. In the face of falling prices Britain was subjected, to enable a return to the gold standard at the pre-war parity, to a deflationary monetary policy which accentuated the fall. Costs, however, lagged behind the fall in prices and neither costs nor prices fell far enough to balance the increased purchasing power of the pound sterling abroad. The pound bought more abroad than at home and the export trade suffered correspondingly while imports were encouraged. At the same time a degree of competition hitherto unparalleled was experienced in world markets and, in an orgy of economic nationalism, tariffs were raised abroad.

Summary

The close of the period shows British pig iron production falling absolutely as well as relatively to the countries compared, steel production and exports falling relatively and imports at a considerably higher level than before the European war. This survey is concluded, therefore, with a picture of retrogression, lack of resilience, depression and continuous unemployment. The remainder of this study is directed to determining the nature and meaning of this retrogression—was it characteristic of British industry as a whole, or the consequence of features special and peculiar to the steel industry? In other words, was it inevitable or was it preventable?

(*c*) An Investigation into whether Retrogression was due to External or to Internal Causes

The retrogression of the British iron and steel industry observed in the above sixty-year review will now be examined to see whether the operative causes were external or internal to the industry.

1. British Output and World Output

The decline of the British output of iron and steel relative to world production is clearly indicated in Table 4 above, showing percentages of world figures, and in Fig. I. Britain's proportion of world output fell, between 1870 and 1930, from 50 per cent for pig iron and 43 per cent for steel to 8 per cent in each case.

As regards pig iron the rate of increase of British output was much slower than that of world output. In the decade following 1920 the trend was actually downwards, whilst world production increased as fast as before the war.

The rate of increase of British production of steel continually diminished throughout the period, as is shown by the steady reduction in the steepness of the curve. Only between 1870–85 was the rate of increase proportionate to that of world production, which maintained a practically steady rate of increase from 1880 to 1913. After 1920 this rate of increase of world output was recovered, but here, too, British output actually fell.

This decline in the ratio of British output to world output may be due to either external or internal factors or both. Other countries followed Great Britain in their industrial revolutions, yet their populations and resources were greater or were increasing more rapidly. In such circumstances it was inevitable that Britain's proportion of total output should fall without reflecting at all on the strength either absolute or relative of the industry. Beginning therefore with the fact that Britain's proportion of total output was falling, further evidence of the circumstances must be sought before conclusions can be drawn.

2. Production Per Capita

(*a*) *Pig Iron.*—In Great Britain the production of pig iron per head of the population increased very slowly from 1870 to about 1904 and then tended to decrease. After the war it was very much lower. The increase in production per head up to 1904, while population was expanding, indicates a steady development of the industry, but the reduced output after 1918, when the population became almost stable, indicates arrested development. This weakness may be due to two causes: the increased use of scrap and the relative decline in steel output.

In the U.S.A., Germany, Belgium and France production per head of the population increased much faster than in this country up to 1913. Britain was surpassed by the U.S.A. in 1901, by Belgium about 1908 and by Germany about 1910. After the war, production per capita in the U.S.A. was little less than the pre-war maximum and in Europe it recovered faster in every country considered than it did in Great Britain. In 1900 this country had the highest production per capita of the five, in 1925–30 the lowest. The rapid

expansion abroad may be due to the later development of the other countries but also to the introduction of the basic process allowing the utilization of the large overseas ore deposits. The conclusion, however, appears to be that after the war the steel industry was demanding less pig iron per head of the population in this country than in other countries.

(*b*) *Steel.*—In 1870 the production of steel per capita was higher in Great Britain than in any other country. It increased, however, more slowly here than in the other four leading countries, and by 1913 the relative positions were U.S.A., Belgium, Germany, Great Britain, France. After the war, production per capita recovered faster in Belgium, U.S.A., France and Germany than in Great Britain which, during this last decade, sank to the lowest place.

One reason for this change in position is undoubtedly the later development of the other countries. On account of Great Britain's earlier industrial development there was already here much iron equipment in use which was retained, while other countries used steel for similar equipment right away. Too much stress should not, however, be placed on this factor of delayed industrial development overseas since, even at the beginning of the period, the standard of living in the U.S.A. was higher in terms of national income than the British. Explanations of the change in the position of Britain must be found in factors other than population growth and general industrial development.

(3) Britain's Home Market Compared with World Demand

(*a*) *Pig Iron.*—In 1870 British consumption was 45 per cent of world output (see Table 7). It began to fall rapidly and during the eighties was about one-third, and during the nineties about one-quarter. By 1913 it was only 12 per cent of world production and during the decade 1920–30 it fell from 12 per cent to 8 per cent.

From 1870 to 1913 the rate of increase of British consumption was approximately one-third of world rate. After 1918 British consumption fell to a greater extent than world consumption and recovered more slowly. In 1930 the former was the same as in 1880, whilst the latter exceeded the 1913 level.

Thus there is clear evidence of a slower rate of development of the industry in this country.

(*b*) *Steel and Wrought Iron.*—From 1870 to 1885 British consumption rose from approximately 13 per cent to 22 per cent of world output;

TABLE 7

BRITISH CONSUMPTION AS A PERCENTAGE OF WORLD OUTPUT AND CONSUMPTION PER CAPITA

	Pig Iron			Wrought Iron and Steel			Consumption per Capita	
Year	British Consumption (a) 000 tons	World Output (b) 000 tons	Ratio (a) (b) (c) %	British Consumption (d) 000 tons	World Output (e) 000 tons	Ratio (d) (e) (f) %	Pig Iron lb	Wrought Iron and Steel lb
1870	5,280	11,800	45	936	7,480	12·5	370	65
1880	6,140	18,100	34	1,608	11,850	13·5	393	103
1885	6,520	19,300	34	3,006	13,300	22·5	400	184
1890	6,860	26,700	25·6	1,936	20,840	9 3	405	109
1895	6,920	28,500	24	3,796	23,130	16·5	390	214
1900	7,740	39,700	19·5	4,580	34,590	13·2	408	248
1905	8,720	52,700	16·5	5,196	49,930	10 4	455	271
1910	9,035	64,700	14	5,382	64,040	8·4	450	268
1913	9,360	77,900	12	7,020	79,380	8·9	457	342
1920	7,680	62,900	12	8,254	73,430	11·2	367	393
1925	6,070	75,690	8	6,995	90,290	7 8	289	334
1930	6,208	79,400	7·8	7,332	93,930	7·8	299	350

after that it fell steadily. By 1900 it was back to about 13 per cent, by 1913 to 9 per cent. Home consumption rose in 1920, but during 1925 to 1930 it was about 8 per cent.

From 1870 to 1890 British consumption increased at least as fast as world consumption. After that period the increase in British consumption slowed down progressively to 1920, whilst world consumption increased at the same rate as before. Between 1920 and 1930 world output increased again though at a slower rate than before 1913, but British consumption remained approximately stationary.

It will be seen that, at the beginning of the steel age, this country had a short-lived relative advantage as a pioneer. After 1920 world economic development was retarded, but British development remained relatively still weaker.

From the above, the following may be concluded:

(1) 1870–85.—World demand was rising faster than British, as Germany and the United States in particular underwent a process of rapid industrialization. There was no basis in home demand for a pig iron output rising at the world rate. Steel consumption at home was rising more rapidly than world, perhaps to be expected in the most advanced industrial country, and British output should have expanded in proportion.

(2) 1885–1913.—The rate of general industrial development overseas proportional to that at home was intensified, British demand was not rising at the same pace as world demand, and if British output had kept pace with world output then it could only have been on a basis of foreign markets.

(3) 1920–30.—The steep fall in the British to world ratio of pig iron consumption may be due partly to the general industrial stagnation, partly to increased use of scrap. The British consumption figures for both iron and steel move against the world trend in 1920–25, indicating the severe relative fall in demand. The margin between steel production and consumption is further narrowed, indicating that, while the home market is restricted, the competitive capacity of the industry is also lessened, which in turn indicates the likelihood of internal factors being at work.

4. Ratio of Consumption to Production in Great Britain

(*a*) *Pig Iron.*—From Table 8 it will be seen that the ratio of consumption to production tended slowly to increase up to 90 per cent in 1913. It rose to 96 per cent after the European war, and in 1930 consumption was equal to production.

TABLE 8

PIG IRON (GREAT BRITAIN)—000 TONS

RATIO OF CONSUMPTION TO PRODUCTION AND OF EXPORTS TO PRODUCTION AND CONSUMPTION

Year	(a) *Production*	(b) *Exports*	(c) *Imports*	(d) *Consumption*	(e) *Ratio Consumption: Production per cent*	(f) *Ratio Exports: Consumption per cent*	(g) *Ratio Exports: Production per cent*
1870	5,960	760	80	5,280	87·5	14·6	12·9
1880	7,750	1,670	(60?)	6,140	80·0	27·2	21·5
1885	7,420	960	(60?)	6,520	88·0	14·7	12·9
1890	7,900	1,100	60	6,860	87·0	16·0	14·0
1895	7,700	870	90	6,920	89·7	12·6	11·3
1900	8,960	1,400	180	7,740	86·4	18·0	15·6
1905	9,610	980	90	8,720	90·7	11·2	10·2
1910	10,010	1,200	175	9,035	90·2	13·2	12·0
1913	10,260	1,120	220	9,360	90·7	12·0	11·0
1920	8,030	580	230	7,680	96·7	7·5	7·2
1925	6,260	460	270	6,070	96·9	7·6	7·3
1930	6,190	272	290	6,208	100·0	4·4	4·4

Till 1913 both production and consumption increased, but the rate of production increase was not as great as that of consumption increase. Internal demand for pig iron (a measure of general economic development at home) was rising faster than pig iron production. The conclusion is that the rate of development of the pig iron industry was lagging behind the general rate of home industrial development. After 1920 the general rate of home development was slower than before 1914; pig iron consumption figures indicate the trend, though they are by no means conclusive evidence (e.g. on account of the increased use of scrap in steel manufacture), but the production decline was still more marked than the consumption decline, emphasizing the previous lag of the iron industry behind general industrial development.

(*b*) *Steel and Wrought Iron.*—Table 9 shows that the rate of increase of consumption was faster than that of production up to 1913, but the rate of increase of consumption slowed down, showing a tendency to reach saturation. There seems to be some indication of a turning point at the end of last century, after which the consumption increased more slowly. After the war period consumption still increased but production fell, and by 1930 consumption practically equalled production.

TABLE 9

BRITISH CONSUMPTION OF WROUGHT IRON AND STEEL

000 TONS

Year	(a) Total Exports	(b) Pig Iron Exports	(c) (a)−(b) Exports less Pig Iron	(d) Total Imports	(e) Pig Iron Imports	(f) (d)−(e) Imports less Pig Iron	(g) (c)−(f) net Exports less Pig Iron	(h) Steel Production	(i) Wrought Iron Production	(j) Production of Steel and Wrought Iron (h)+(i)	(k) Consumption (j)−(g)	(l) Ratio Exports (c) Consumption: %
1870	2,730	760	1,970	156	80	76	1,894	220	2,610	2,830	936	210
1880	3,650	1,670	1,980	348	(60?)	288	1,692	1,290	2,010	3,300	1,608	123
1885	2,040	960	1,080	346	(60?)	286	794	1,890	1,910	3,800	3,006	36
1890	3,900	1,100	2,800	386	60	326	2,474	3,580	1,930	5,510	3,036	92
1895	2,800	870	1,930	406	90	316	1,614	3,260	1,150	5,410	3,796	51
1900	3,500	1,400	2,100	800	180	620	1,480	4,900	1,160	6,060	4,580	46
1905	3,800	980	2,820	1,356	90	1,266	1,554	5,810	940	6,750	5,196	56
1910	4,600	1,200	3,400	1,367	175	1,192	2,208	6,370	1,120	7,590	5,382	63
1913	4,980	1,120	3,860	2,230	220	2,010	1,850	7,660	1,210	8,870	7,020	54
1920	3,250	580	2,670	1,107	230	877	1,793	9,070	977	10,047	8,254	32
1925	3,750	460	3,290	2,720	270	2,450	840	7,390	445	7,835	6,995	47
1930	3,157	272	2,885	2,908	290	2,618	267	7,330	269	7,599	7,332	39

It may be concluded that if there is no objection to taking wrought iron and steel together (except that one does not get steel figures alone) this relative decline of output in relation to consumption indicates some inefficiency in factors internal to the industry. Internal factors certainly seem responsible for what appears to be a relative weakness of the home iron and steel industry, both in relation to (*a*) steel-consuming industries and (*b*) overseas producers.

The steep growth in imports stresses the relative weakness of the steel-producing over the steel-consuming industries.

The fall in the rate of consumption indicates a setback in the general rate of economic development accountable by other than technical factors, yet the relatively greater setback in iron and steel leads to the assumption that internal factors did have a special influence.

5. British Consumption Per Capita

The consumption of iron and steel per head is an indication of the level of industrial development and countries which have followed Britain in development may be expected to enjoy a more rapid per capita increase as they come into line.

(*a*) *Pig Iron.*—In 1870 the consumption per capita was 370 lb. It rose to approximately 400 lb., at which it remained steady till the end of the century. Consumption then rose to 450 lb. per capita, where it again remained steady till 1913. In 1920 it had fallen to about the same as in 1870, and during the decade fell below 300 lb. per capita.

In Great Britain consumption per capita in 1870 was highest of all countries and increased very slowly from 1870 to 1913. In the U.S.A., Germany, Belgium and France it increased rapidly and by 1913 consumption per capita was higher in Belgium, U.S.A. and Germany than in Great Britain. After 1920 consumption per head maintained its pre-war value in U.S.A., Belgium and Germany, in which countries it exceeded that in Great Britain, with France following closely behind.

(*b*) *Steel and Wrought Iron.*—Allowing for fluctuations, the consumption per capita had a steady upward trend from about 65 lbs. in 1880 to 342 lb. in 1913, less than 80 per cent of the corresponding figure for pig iron. In 1920 the consumption was nearly 400 lb. per capita, and during 1925–30 it was approximately the same as in 1913.

From the above a slowing down of the general rate of industrial development in Britain is indicated. The pig iron figures show that consumption per capita ceased to increase soon after the turn of the century. The steel figures also suggest a retardation of development if it can be assumed that the upward leap prior to 1913 was due to pre-war rearmament. The decline in the pig iron figure after 1920 is probably due to the greatly increased use of scrap while the lack of any expansion in the post-1913 steel figures supports the suggestion of a serious slowing down in the general level of industrial development. In other words, the demand for steel remained static in the post-war decade, indicating a relative stagnation of the steel industry compared with industry in general. In contrast we may note there was a heavy re-equipment of industry in Germany after 1920, and in the U.S.A. the steel industry developed on the basis of making capital goods for export.

CONSUMPTION PER CAPITA. FINISHED IRON AND STEEL (INGOT EQUIVALENT)

Year	*Britain* *lb.*	*Germany* *lb.*	*France* *lb.*	*Belgium* *lb.*
1913	330	405	238	326
1924–25	363	332	266	246
1929	400	396	363	418

6. BRITISH HOME MARKET AND FOREIGN TRADE

(*a*) *Pig Iron*.—Table 8 shows that pig iron consumption rose steadily from 1870 to 1913, increasing by approximately 75 per cent. After the war it fell, being about the same in 1920 as in 1900, and from 1925–30 approximately the same as in 1880.

Exports of pig iron were broadly speaking just above 1 million tons per annum from the beginning of the period to 1913. Expressed as a percentage of the home market, therefore, they steadily declined from approximately 20 per cent to 11 per cent. In the decade 1920–30 exports fell precipitately, being 7·5 per cent of consumption in 1925 and 5 per cent in 1930.

It may be concluded from the stationary position of pig iron exports, in spite of a rapidly rising world demand, that the home industry was not strong enough to compete with the development of the overseas industries. The position in the decade 1920–30 particularly suggests internal weakness.

Quantitatively, exports were maintained, but they fell in relation both to output and consumption. At the same time, however,

world production was expanding, hence the potential market for British exports was growing. The fact that this market did not expand, while home consumption was expanding, again emphasizes the above conclusion on the relative backwardness of the home iron industry—in this case the backwardness is in relation to the development of the industry overseas.

(*b*) *Steel and Wrought Iron.*—Consumption rose much faster between 1870 and 1913 than for pig iron, approximately 600 per cent compared with 75 per cent. Moreover, the consumption of steel continued to rise till 1920, and whilst it fell in the following decade it was still at about the level of 1913, again contrasting with pig iron.

Exports of wrought iron and steel were higher in the decade 1870–80 than consumption. From 1885 onwards they were lower, but in the new (steel) era they increased at about the same rate as consumption. From 1895 to 1913 exports were just over 50 per cent of consumption. After the war period they fell, and from 1925 to 1930 were just over 40 per cent of consumption. Expressed as a percentage of home trade the export trade fell from over 100 per cent at the beginning of the period to 50 per cent in 1913 and to 40 per cent in 1930.

In view of the rapid rise in world consumption the decline in the export trade indicated an inability to compete against the new sources of production. Even if home demand were not rising, or only rising slowly, the increase in overseas demand opened opportunities for the export trade, but it appears that such overseas markets were more than met by overseas producers.

Summary

The above points may now be summarized as follows:

(*a*) The ratio of British output to world output declined, but this may have been either due to external or internal factors. The development of new countries, the spread of industrialization, and the development of new techniques will always be accompanied by a widening of the field of production. It would be absurd to expect the early centres of production to maintain their degree of relative importance. At the same time it is possible that factors internal to the industry in the old-established areas were holding back its development.

(*b*) The ratio of British consumption to world output declined. The ratio of home demand to world demand fell. Here we have the

existence of the external limiting factor noted in (*a*) above verified. The native industry can, of course, supply the foreign market, but the spread of industrialization abroad implies that neither steel exports nor exports of goods made from steel, can expand at the same rate as the overseas market.

(*c*) The ratio of British output to British consumption declined. Here no external factor such as the development of new resources abroad is lowering the ratio of British output on the whole. If the British output actually begins to fall behind the home demand, then clearly the home industry is losing ground to the industry abroad under circumstances that show internal weakness.

(*d*) The ratio of British export trade to British home trade declined. This must have been due mainly to internal factors, for world demand and, therefore, export opportunities, were increasing faster than home demand. Clearly the industry reveals a relative weakness in overseas competition.

(*e*) The ratio of British imports of iron and steel to total imports increased. The British economy was expanding more slowly than the world economy; it was natural that imports should rise, but for the imports of a basic industry to increase more rapidly than total imports indicates a relative backwardness of the steel producing to the steel consuming industries.

(*f*) The ratio of British exports of iron and steel to total exports remained approximately constant in value but fell in volume. In an expanding world economy, however, there is a particular demand for iron and steel products, since iron and steel is the basis of all industrialization. The opportunities that rising world demand offered the industry were not taken; this can only suggest once more a relative weakness in the British industry.

(*d*) Some Evidence on the Competitive Power of the British Iron and Steel Industry

The three preceding sections have shown first the broad facts of British iron and steel production and trade in relation to the rest of the world followed by a more detailed study of the development of the industry at home and abroad. After concluding that the British industry experienced a relative and, in some respects, an absolute decline, the data were investigated to see whether this appeared to be due to factors within or beyond the control of the industry. Although we have considered the British iron and steel industry in relation to the industry abroad, before proceeding in the

next chapter to study the external factors, it will help to picture more fully the national environment of the iron and steel industry if we examine some additional data on the competitive power of the industry in relation to other British industries. Did the iron and steel industry show any peculiar strength or weakness in comparison with other industries? Did the iron and steel industry operate under any special domestic conditions? Without making any attempt to treat the subject exhaustively—for to do so would involve a detailed study of the structure of the whole British economy—some light may be shed on the first question by a study of British foreign trade in iron and steel, compared with her total foreign trade, and by an examination of the census of production. The second question may be answered in part by a study of the unemployment figures for the metal-using industries, compared with those for all industry, and of demand in an important consuming industry, such as shipbilding. Such data can claim to be no more than illustrative.

1. British Foreign Trade in Iron and Steel compared with the Total for the Country

Table 94 (Appendix) gives the tonnage and value of iron and steel exports and imports for Great Britain between 1867 and 1930, and Table 95 (Appendix) shows the country's total foreign trade in sterling. A comparison between iron and steel and total foreign trade is made in Table 96 (Appendix) and Fig. V (page 63).

(1) Imports: Up to 1913 the rate of growth in value of total iron and steel imports was greater than that of the growth of the total imports of the United Kingdom. At the beginning of the period, iron and steel imports were averaging just over 130,000 tons (£1½ million) but by 1913 they had increased to 2 million tons (£13 million). The country's total imports, however, only doubled in value over the same period from some £300 million to over £600 million. In the post-war period, iron and steel imports continued to increase and by the end of the twenties were nearly 3 million tons (£24 million). The trend in value of total imports was similar and a figure of £1,100 million of retained imports was reached. The average value per ton of iron and steel imports at the three periods mentioned was £11½, £6½ and £8, respectively. It is clear that, although dependence on imports was growing, the tendency, allowing for the post-war rise in prices, was to import progressively lower qualities.

The increase in total imports in the post-war period is evidence of Britain's creditor position, but the increase in the rate of steel imports compared with total imports suggests that the increased demand for steel, consequent on the general expansion in trade, was being met to a relatively greater extent from overseas sources.

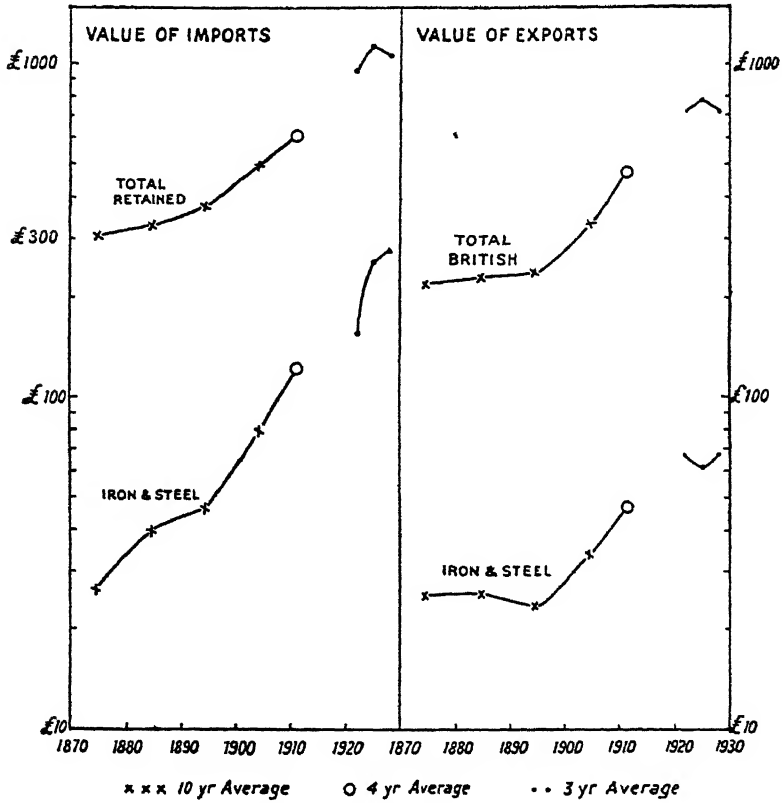

FIG. V (Ratio Scale £Mn.)

VALUE OF BRITISH IRON AND STEEL IMPORTS AND EXPORTS COMPARED WITH TOTAL

This again suggests the relatively backward nature of steel production, as compared with production in the steel consuming industries (see (*e*) above, page 61).

(2) Exports: Before 1913 the rate of growth of total iron and steel exports was less—approximately one-third—than that of the rate of growth of total exports of the United Kingdom. At the

beginning of the period iron and steel exports were just under 2½ million tons (£21 million) and they had nearly doubled by 1913. The value of total exports increased from under £200 million to some £500 million over the same period. After the war, omitting the immediate post-war period, both the exports of iron and steel and total exports tended to fall. The volume of United Kingdom exports remained, however, above that of 1913 and the value rose to some £700 million. The volume of iron and steel exports, on the other hand, fell to under 4 million tons (£65 million). The value of iron and steel exports per ton at the three periods mentioned was £8½, £11 and £16 respectively. Although exports pre-war did not increase rapidly and decreased post-war, the quality of the exports progressively rose.

The simple conclusion from the above is that the competitive position of iron and steel was not as strong as that of other trades. With production growing at home and abroad prior to 1913, iron and steel exports expanded, but their rate of growth lagged behind that of the expansion in total exports on account of a relatively inferior competitive position. Had the competitive position of the iron and steel industry not been inferior it would be expected that their exports would have expanded pro rata with other exports, save indeed, to the extent that protectionism abroad would be more concerned with assisting native steel as opposed to other industries. (see (*f*) above). The facts of the export trade suggest that before 1913 the home industry was growing (*a*) at a lower rate than general home production, and (*b*) at a lower rate than world production and the world iron industry. After 1913 these conclusions are reinforced, for the particularly rapid quantitative fall in exports, compared with the quantitative fall in home consumption, is evidence of the nature of the relative increase in productive strength overseas.

It is noteworthy that imports became progressively of lower quality and exports of higher quality. At the beginning of the period the value of a ton of exports was only 75 per cent of a ton of imports—this country exported cheap iron and steel and imported the higher grades. By 1913 the proportion had changed to 170 per cent, and by the end of the period to 200 per cent, bearing out the suggestion that the British industry was becoming more of a finishing trade.

2. Unemployment

Did unemployment in the iron and steel industry tend to vary from the general trend and can any conclusions be drawn from this as to the relative strength of the industry?

Between 1870 and 1913 the three-year moving averages of the unemployment figures show that the percentage of unemployment was higher in the metal, engineering and shipbuilding industries than in industry in general; only slightly higher in times of good trade but approximately 30 per cent higher in times of depression. This, however, is what one would expect to find in the capital goods industries where unemployment fluctuations are always greater than in the consumer goods industries.

From 1913 to 1920 the unemployment figures among trade union members were low, while during the war, as might be expected, the metal, shipbuilding and engineering industries had lower figures than for industry as a whole. Immediately after the war the two sets of figures were identical but the post-war period was an exaggeration of pre-war conditions. From 1921 to 1930 unemployment among insured workpeople was higher than before 1913, varying between 10 and 17 per cent. Unemployment among trade union members in metals, shipbuilding and engineering was considerably higher, varying between 13·5 and 27 per cent (including the strike year 1926), while in the iron and steel industries it was higher still, varying between 18 and 39 per cent (or 25 per cent, excluding 1926).

Fig. VI shows the pre-war curves for unemployment in general and in the engineering, shipbuilding and metal industries. Two things stand out clearly: (i) the greater degree of fluctuation in the latter, which also show a permanently worse experience than industry in general, and (ii) the widening margin between the two curves. In the first decade, 1860–70, the metals curve ran 16 per cent higher than the general; between 1880–90 the margin was 26 per cent, and between 1900–10 40 per cent.

The detailed figures for shipbuilding shown in the Appendix (Tables 100 and 101) reinforce the only reliable conclusion that can be drawn from the unemployment figures, that is, that the iron and steel industry, as the basis of all capital goods construction, is not only the most subject to cyclical fluctuations, but has become increasingly so. This experience, common though it may be to all countries, helps to explain the importance of the struggle for export markets to the industry in each country. An industry subject to fluctuations in demand tends to build capacity to cope with the peak demand. This is the more so when the industry is highly competitive, or when—as in iron and steel—the industry is a basic war industry and is forced to expand capacity to cope with the

peak armament demand. In time of slump, however, excess capacity presents a serious problem of overheads, and in order to utilize capacity as fully as possible when the internal market is saturated a fierce struggle develops to maximize exports. The struggle is the fiercer for the facts that (*a*) industrialized countries experience their slumps in phase so that they are all aiming at increasing their exports at the same time; (*b*) the markets are also victims of the slump and their total demand is less than in times of good trade.

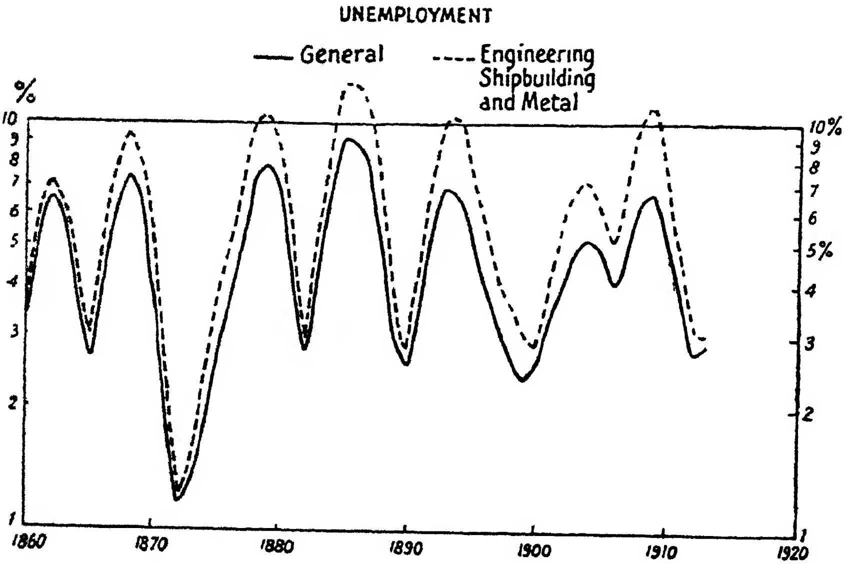

FIG. VI

PERCENTAGE OF UNEMPLOYMENT IN BRITAIN (GENERAL COMPARED WITH ENGINEERING INDUSTRIES)

See Appendix for annual figures (Table 99).

In the pre-war period it is clear that the importance of an export market as a buffer to the home market steadily increased.

3. Shipbuilding

Shipbuilding provides an interesting illustration of the external factors which have faced the British capital goods industries, among them the iron and steel industry. In 1888 92·7 per cent of vessels under construction were built of steel and in 1892 97·5 per cent. Here, then, is a major consumer and the kind of market it provides is shown in the following table and Fig. VII.

SHIPBUILDING: VESSELS LAUNCHED (000 TONS)

Annual Average	*United Kingdom*	*Abroad*	*Total*	*United Kingdom as per cent of total*
1892–1901	1,180 (1,308)	495 (653)	1,676 (1,961)	71 (67)
1902–1911	1,375 (1,506)	914 (1,177)	2,289 (2,683)	60 (56)
1912–1921	1,433	2,337	3,770	38
1922–1931	1,101	1,149	2,251	49

The figures are for mercantile vessels. The total including warships, where known, is shown in brackets. See Appendix for complete table (No. 100).

World launchings rose rapidly until the post-war decade, though in the United Kingdom far less rapidly than abroad. In the final decade there was a heavy slump and the world total fell to that of the pre-war level, while the British figure fell even further to its level of the nineties. So far, therefore, as the world iron and steel industry is concerned, shipbuilding provided a rapidly increasing demand till after the war, when it fell off to the level of the early part of the century. In the United

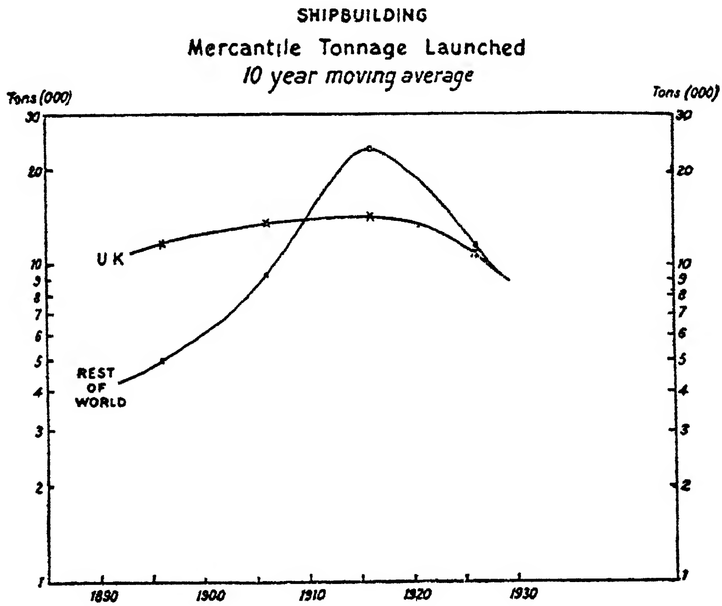

FIG. VII

SHIPBUILDING—TOTAL TONNAGE LAUNCHED IN THE U.K. AND THE WORLD

Kingdom, however, the iron and steel demand for shipbuilding was double that of the rest of the world in the nineties, after which time it rose far more slowly till it was surpassed during the war. In the post-war decade it practically equalled that of the rest of the world. Even had it been possible for the British iron and steel industry to provide the material for shipbuilding abroad, its post-war market must have shrunk, although actually the British shipbuilding industry did not slump to the extent of that abroad. To conclude, right down to the post-war period the relatively slow growth of home demand was a limiting factor in the demand for iron and steel.

4. The Census of Production

Finally, there is the evidence provided by the Census of Production, of the development between 1907 and 1930 of the iron and steel industry in relation to others. The steel industry is the only major one the gross output of which decreased (Table 10). The figure for 1924 was, it is true, higher than for 1907, but the slight increase was eclipsed by the jumps made in textiles, chemicals and coal. Between the two censuses of 1907 and 1924 there was a fall, too, in the number of employees in the iron and steel industry, but this fact in itself is no indication to the degree of efficiency obtaining.

Between 1907 and 1924 the net output per person employed in the industry increased by less than 90 per cent (these figures are only valuable for comparative purposes, the change in the value of money invalidating the significance of the absolute increase), against 130 per cent in textiles and 105 per cent in chemicals. On the other hand, the rise in engineering was no greater and that in shipbuilding and coal much less. If the comparison is extended to 1930 the overall increase for iron and steel becomes 75 per cent, for textiles 83 per cent and for chemicals 129 per cent. The conclusion appears to be that over the period considered the efficiency of the iron and steel industry, as measured by the net output per person employed, did not increase to the same extent as that of other basic industries. The lag, however, is not so striking as to suggest that of all British industries the iron and steel was outstandingly the most backward. The industry may have been backward by comparison with some of its overseas rivals, but it was not markedly the least efficient of all the home industries, although in the less efficient group.

TABLE 10

GREAT BRITAIN; CENSUS OF PRODUCTION DATA

	Year	Iron and Steel Industry	Textile Industries	Chemical Industries	Coal	Shipbuilding	Engineering Trades	Non-Ferrous Metals
Gross Output, £ mn.	1907	330	333	75	122	42		
	1912				122	48		
	1924	369	757	226	251	54		
	1930	237	432	181			401	95
Employees, 000	1907	523	1,253	155	838	188	732	114
	1912				979	186		
	1924	557	1,256	207	1,198	143	993	123
	1930	493	1,062	178				
Net Output per person employed, £	1907	106	76	179	127	98	107 109	104
	1912		81		107	111		
	1924	198	175	369 375	175	170	201	214
	1930	186	139	409				
H.p. available per person employed	1907							
	1912		1 80					
	1924	5·9	2·00	3·1	3 0		2·1	2·2
	1930		2·45	3 8				
Power-equipment, 000 h.p. (1) Prime-movers (2) Electric motors		(1) (2)		(1) (2)	(1) (2)	(1) (2)	(1) (2)	(1) (2)
	1907	1,597		265	2,291	114	491	84
	1912	1,655 404		296 89	2,520 115	61 72	447 520	94 41
	1924	1,993 1,372		418 344	3,150 463	46 334	499 1,636	123 195
	1930							

Summary

One may conclude this section by remarking that the British iron and steel industry was somewhat weaker than other British industries in exports, while it permitted an increased ratio of imports to supply the home market.

It suffers from the problems of a capital goods industry in an extreme degree and requires more co-operation, (*a*) to prevent the building of excess capacity and for the most economic usage of capacity in time of slump, and (*b*) to hold its own in both the home and the overseas market, particularly in the face of intensive competition.

Chapter I set out to study the development of the iron and steel industry. It has shown that both as regards output and exports the industry in Great Britain has lagged behind the rest of the world both absolutely and relatively. While Great Britain began with certain differential advantages, these were lost through neglect of developing technique, which was accentuated as the period advanced, while in the post-war decade monetary policy and State neglect hampered the domestic industry still further.

A theoretical examination of the movements in British production, consumption, imports and exports, both in relation to world trends and to the trend of other sections of British industry, leads to the conclusion that factors both internal and external to the industry were responsible for its changing fortunes. The problem being thus stated, it remains now to study the general environment of the industry and its internal development in order to attempt to assess the relative weights to apply to the various causes of decline. Without a clear understanding of these causes the true remedies cannot, of course, be found.

CHAPTER II

Natural, External or Inevitable Factors; Evidence of a General Industrial Retrogression of the Country as a Whole

External Factors Affecting the Development of the Industry

At the beginning of the steel age no country worked under more favourable conditions than Britain. We had extensive deposits of coal and ore in close proximity for the cheap production of pig-iron and some of the best coking coal occurred near seaboard where the world's best ores could be imported at low freights. We had industries of the first order, coal, ores, works, plant and machinery, and inherited metallurgical skill. In the construction of locomotives and ship-building we always led. Our trade position geographically was very favourable and we enjoyed political and economic strength and stability.

The war of 1914–18 produced serious changes—for instance, some of the old trade outlets had been disturbed and many had disappeared—but we still had the advantage of location of the coalfields, and of most of the iron works being near the coast, as well as the pre-eminence of the British mercantile marine.

Could, then, the history of the iron and steel industry have been otherwise than as described in the preceding chapter? What was the general economic framework, national and international, in which it had to operate? The present chapter sets out to examine the natural, external or inevitable factors that affected, and perhaps governed, the development of the industry and to sift the evidence of a general economic retrogression or of a retardation of the general industrial development of the country as a whole; for it is possible that the relative decline of iron and steel was no more than symptomatic of a general industrial retardation in Great Britain, or of a change in Britain's economic power in the world economy. If these are the explanations, the cure, as well as the causes, for the decline must be sought outside the industry.

(a) Economic Development

1. Increasing Industrialization Abroad

The iron and steel industry is fundamentally a producer of capital goods; it can only expand to supply an economy in which demand is rising—though the rise may come about from such opposite causes as an improving standard of living or a war. In a period of rapid industrialization, the demand for iron and steel is growing, and during the period under review one of the most important factors affecting the world position of Great Britain was the rapid industrialization of other countries. In 1870 this country was the most highly industrialized in the world and it is not surprising to find that it enjoyed in particular a considerable lead in the iron and steel industry and supplied the greater part of world demand. Much of the demand came from the expanding economies of other countries, to which the United Kingdom not only exported quantities of machinery but also the skilled men to work it, who subsequently undertook its production both in Europe and America.

The depression of the seventies in Europe stimulated emigration to the U.S.A., a country rich in natural resources, but where the scarcity of labour, and particularly of skilled labour, gave a strong impetus to mechanization, and where long distances caused the rapid development of large-scale transport. With a rapidly growing population—from natural increase as well as immigration—and abundant iron and fuel resources, industrialization in the States spread rapidly westwards after the Civil War.

Germany, in spite of her fuel resources, was not particularly well endowed by nature, but following her seizure of the iron resources of Lorraine was in a position for industrial development which she rapidly exploited with her national gifts for organization and the commercialization of scientific discoveries. Her population, like that of the U.S.A., increased faster than that of this country.

Industrialization also gathered momentum in Belgium, France and other countries, where the comparative inexperience of the workmen favoured the introduction of more purely mechanical processes, so that not only did western countries cease to lag behind Great Britain in industrial phase, but in the U.S.A. and Germany the mechanization of industry and large-scale production developed faster than here.

Broadly speaking, therefore, the first four decades of the period under review (1870–1910) were a time of rapid industrial and

commercial development of our chief competitors, who, following in our footsteps, fostered the growth of the same group of exporting industries. The difference was, however, that these foreign countries developed those sections of industry which were largely standardized, whilst manufacturers here developed the less standardized forms—a feature shared by the British iron and steel industry.

By the end of the century it was noticeable, and before the war of 1914–18 obvious, that this country had not retained her quantitative industrial lead, and that her previous high proportion of the world production of manufactured goods had decreased considerably. In illustration of this point, British steel production was surpassed by the U.S.A. in the nineties and by Germany in the first years of the present century. By 1913 these countries had also surpassed Britain in the production (and export) of mechanical and electrical machinery, and it was noticeable that this country lagged behind in the development of industries founded on the new scientific discoveries, e.g. in electrical and chemical products.

The war of 1914–18 caused a dislocation of world trade and those countries which could not obtain manufactures from the belligerents had to set up in production for themselves. After the war, countries which had previously been almost entirely engaged on primary production fostered factory production, regardless of real cost, and countries with low standards of living were industrialized.

The U.S.A. advanced continuously in industrial strength during the war and post-war periods. In Europe after 1918 much industrial reconstruction was carried out from reparations (physical reconstruction in France and Belgium, re-organization in Germany), or as a hedge against currency inflation. It is interesting to note that France and Belgium re-equipped their steel works at Germany's expense, while the steel-makers of the Ruhr also benefited from the volume of work they handled on reparations account! In this country, however, no such reconstruction was made and the big plants built during the war were not adapted to peace-time demands. The special monetary and financial difficulties which militated against modernization and which are considered below, burdened British industry. As a consequence of these difficulties, the industrial position of this country after the war was relatively further weakened. The indices of production in the various industrialized countries showed that the lowest rate of increase was in Great Britain. Moreover, a change was apparent, shown in a decline in the industries in which this country had specialized in the past: not only were the

older industries declining, but the growth of the newer and growing industries was relatively slow. In spite of a continually growing world output, the volume of production in this country in the twenties was not greater than in the last pre-war years, and our percentage of world manufactures continued to fall.

The advantages which the process of natural development, as it may be termed, has conferred on the iron and steel industry in countries of larger area and greater potential resources than the United Kingdom are strikingly brought out in the accompanying tables showing railroad mileage. Table 11 shows that, while in Great Britain the mileage of railroad completed increased between 1870 and 1899 by little over 6,100 and in the next twenty years by 2,000, in France the increases were respectively 15,000 and 5,800; in Germany, 19,600 and 6,500, and in the U.S.A., 136,000 and 63,900. Put in another way, while over the fifty years 1870–1920 railway mileage in Great Britain increased by 53 per cent, in Belgium it increased by 61 per cent, in France by 190 per cent, in Germany by 240 per cent, and in the U.S.A. by 380 per cent. Taking the world as a whole, the increase was 430 per cent, or, in terms of absolute mileage, 551,000, of which Britain's share was 8,200.

Assuming that all track was double, although in fact much mileage outside this country, especially in U.S.A., was single track, the average annual demand for iron and steel tonnage over the period as a result of new railroad construction may be approximately estimated at 40,000 tons in Great Britain against 104,000 in France, 130,000 in Germany, and 1,000,000 in U.S.A.

TABLE 11

RAILWAYS

MILES OF ROAD COMPLETED, 1870–1930

Year	*Britain*	*U.S.A.*	*France*	*Germany*	*Belgium*	31 *Principal Countries*
1870	15,537	52,922	11,142	11,729	1,799	127,887
1880	17,933	93,296	16,275	20,693	2,399	221,372
1889	19,943	160,544	21,899	24,845	2,776	347,218
1899	21,666	189,295	26,229	31,386	2,883	452,579
1910	23,280	236,422	29,364	36,235	2,888	582,184
1920	23,725	253,152	32,030	37,094	2,913	678,895
1930	20,392	249,052	39,627	36,269	3,159	700,000 (approx.)

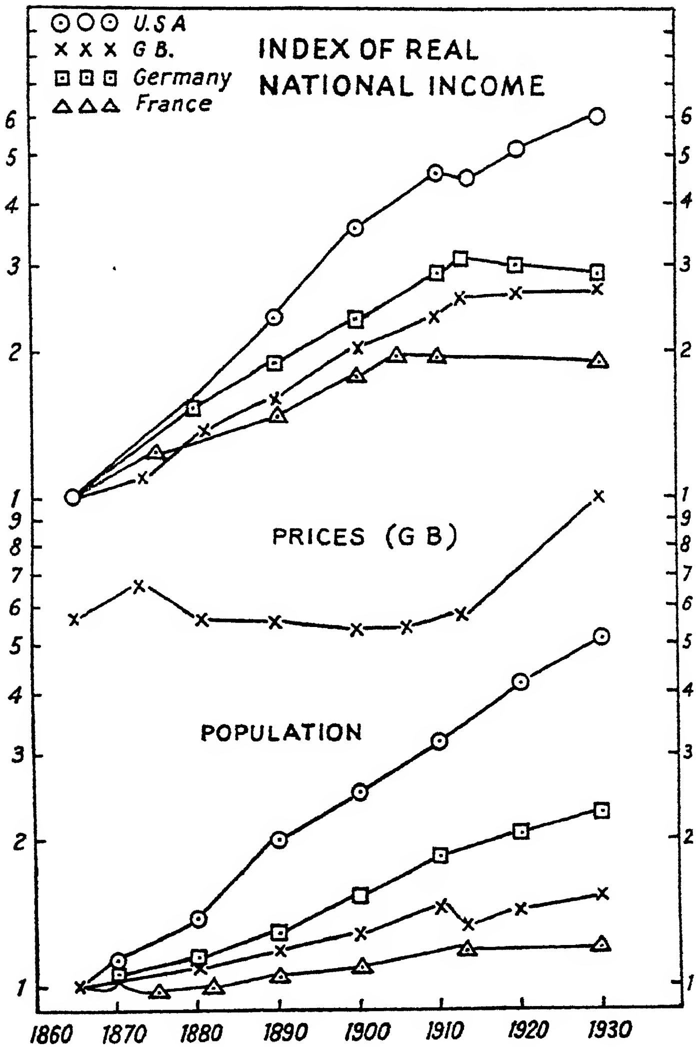

FIG. VIII

POPULATION AND REAL NATIONAL INCOME, 1870–1930

2. Population

The trends of population and national income are excellent guides to the capacity of the market to absorb industrial goods and serve to show in which countries the native interests have the advantage

of an expanding home market. The population trend in the leading countries is shown in the following Table 12 and in Fig. VIII.

TABLE 12

Occupied Population (Actual) in Millions

Year	*United Kingdom*		*U.S.A.*		*Germany*		*France*	
1865	1860–69	13·7	1860–70	11 7	1854–76	12·0	1860–79	15·0*
1890	1886–93	16·5		23·3	1886–93	15·9	1880–99	15·5*
1913		20·8 (18·4)		39·3		23·0	1911	17·7*
1930		(21)		48·9	1925–30	27·2*		18·2

Occupied Population (Index Numbers)

Year	*United Kingdom*	*U.S.A.*	*Germany*	*France*
1865	100	100	100	100
1890	120	199	132	103*
1913	152 (134)	336	192	118*
1930	(154)	418	227*	122

* Exclusive of Alsace-Lorraine. Figures in brackets exclude Eire.

See Appendix for complete tables (pages 288, 289).

While between 1865 and 1913 the working population of the United Kingdom rose to half as much again, in Germany it was nearly doubled, and in the U.S.A. it was more than trebled. An increased population means an increased demand for constructional steel, for steel for machinery, for railways, for transport generally. Those countries in which the population expanded most rapidly were countries in which the internal demand for steel rose most rapidly; in this respect Germany and the U.S.A., but especially the latter, enjoyed a considerable advantage over the United Kingdom. Yet it must not be ignored that France, whose population growth lagged behind that of the United Kingdom, nevertheless forged ahead of this country after the European War in iron and steel production. A restricted internal market is not, therefore, an adequate explanation of a lagging industry. External markets also present opportunities.

3. National Income

The national income represents the total demand of the nation for goods and services. Its size and rate of growth, too, can be taken as a guide to the potentialities of the home market for iron and steel. The following table shows the trend in the leading countries:

TABLE 13

REAL NATIONAL INCOME

(Actual in terms of 1925–34 prices)

Year	United Kingdom £ millions		U.S.A. $ thousand millions		Germany marks thousand millions		France francs thousand millions	
1865	1860–69	1,595	1860–70	11·7	1854–76	23·4	1860–69	124·6
1890	1886–93	2,548		27·2	1886–93	44·1	1880–99	189·4
1913		4,120		52·5		73·1	1911	246
1930		4,318		70·7	1925–30	67·2		235

REAL NATIONAL INCOME

(Index numbers)

Year	United Kingdom	U.S.A.	Germany	France
1865	100	100	100	100
1890	109 5	232	188·5	152
1913	258	448	312	197·5
1930	270·5	604	287	188·5

See Appendix for complete tables (pages 289, 290).

While between 1865 and 1913 the total income of the United Kingdom multiplied itself two and a half times (against a one and a half times increase in population), that of the U.S.A. multiplied itself four and a half times, and that of Germany over three times. Clearly the internal market in Britain grew far more slowly than it did in either Germany or the U.S.A., but here again it must be noted that the national income of France lagged behind that of the United Kingdom and that nevertheless the iron and steel industry of France did not lag behind that of the United Kingdom.

The standard of living in Great Britain as measured in terms of income per head of the working population (in work and unemployed) on the basis of a forty-eight-hour week, rose rather more rapidly than in any other country between 1870 or 1875 and 1913 (although in absolute terms it was always below that in the U.S.A.). By 1913 the increase in Great Britain was 77 per cent, in the U.S.A. 63 per cent, in France and in Germany 53 per cent. It is not, however, the standard of living that determines the total internal demand, but the total income as set out in the previous paragraph. The rise in income per head is nevertheless a measure of productivity, making due allowance for income derived from overseas (see Appendix, Table 104). Productivity appears to have risen more

rapidly in Great Britain than in other countries, yet the development of the iron and steel industry lagged behind. This gives the impression of a relative lag; something out of line with the general development of industry in the country.

The two preceding sections have shown the growing industrialization of other countries and their more rapid increases in population and income. These factors are pointers to the reduction of Britain's share of world production and suggest that the loss of her industrial supremacy was inevitable. Other countries are as well, if not better, endowed in natural resources, can support larger populations, have larger internal markets which have assisted large-scale production to develop further than in this country. On general grounds, therefore, just as British production was first overtaken and then surpassed by that of other countries, so it is reasonable to expect a relative decline in the British iron and steel industry. Yet even if it is accepted that the economic development of Great Britain was out of phase with that of the rest of the world, the factors above mentioned do not sufficiently account for the relative decline to the extent that actually took place. If the home market does not expand as rapidly as in other countries, then the iron and steel industry is denied an important advantage; but this does not explain why this country should have been outcompeted in some portions of the export trade, particularly, for example, in certain branches of the finishing trade where skill and experience count most. In France both population and income, the two factors that reveal the growth of the internal market, lagged behind Great Britain, yet the steel industry progressed more rapidly.

There still remains to examine a number of factors governing the environment of the iron and steel industry, but over which the industry had no control.

(*b*) Changes in Industrial Flexibility

Industrial evolution is continuous. With the lapse of time new sets of economic and industrial conditions arise—in technology, in organization and in technique—which disturb the balance of industrial power between countries and lead to increased international competition and a struggle for markets. Under these changed conditions a given country may function to less advantage than hitherto in relation to its competitors, who may adjust themselves more favourably to the change. If this country has shown, on the whole, less adaptability to new industrial methods and organization, and a

slower acceptance of changing technique, a lag in development of a particular industry may rank for inclusion in the factors within the control of that industry only in so far as the lack of flexibility is beyond the average. Even this is a moot point, however, as each industry in each country can be held responsible for maintaining its own initiative.

During the latter part of the 19th century a relative British conservatism with respect to technical progress induced a general lag in the march of efficiency, and the iron and steel industry was only a typical case, though this does not exonerate the industry from responsibility.

An examination of the constituents of total British exports indicates a lag in development of highly skilled production from the beginning of the present century, as an advance was recorded only in coal and the products of industries employing unskilled or semi-skilled labour. Even in coal the yearly output per miner had fallen since 1880 and the price had risen in relation to the general price level, whilst in the U.S.A. and in Germany production per man had risen and remained constant. In those industries where science counted for more than natural conditions, e.g. chemical and electrical industries, this country showed a lag in development. Before the war of 1914–18 we could hardly compete in electrical products with Germany, which had practically a monopoly of world export trade; our supremacy in textiles was challenged; in chemicals and other products it had passed, and the question was already being asked whether this country had any enduring advantage in industry and trade.

Due to scientific and technical advances, productive capacity could be created equally rapidly in foreign countries as here, and it had become easier for them to pass from the coarser to the finer products of industry. Moreover, the introduction of automatic machinery had made the productivity of low paid and low grade labour in foreign countries equal to that in our own.

After the war a lag in the adjustment of the whole machinery of our production and distribution to changing conditions was more noticeable. Changing demand made flexibility particularly desirable, but our methods of production and organization were not as elastic as they should have been.

The allowed rate of obsolescence on plant in this country was lower than abroad, labour costs were more rigid due to the power of organized labour, and re-organization was carried out in small

doses which, as might have been expected, were of little use to solve the main problem.

Rigidity of the mechanism of national production is evidenced by lower exports during 1920–30 to Asia and North America, as well as to the Continent—we failed, in fact, to secure a proportionate quota of trade in regions least affected by the war as well as in those impoverished by it. Moreover, whilst Continental countries were more gravely injured by the war, they had by 1930 shown in general a greater degree of recovery in world markets.

Unfortunately the early British leadership in the iron and steel industry induced complacency rather than a determination to keep ahead, as may be illustrated by the following description of the American iron industry quoted from the journal *Iron* for December 19, 1879.

"The American iron industry—this incompetent, intrinsically worthless and hopelessly unsuitable industry to continue standing on its feeble, tottering, artificial wooden legs. . . . "

In the sections on factors under the control of the industry the question of works practice in the iron and steel industry will have to be considered, but at this stage it will be sufficient to indicate that the earlier development of the steel industry in this country resulted in a larger proportion of old plant than abroad, rendering its adjustment to changing conditions more difficult. Pig iron production was mostly carried on apart from that of steel and the size of the typical plant and normal firm was smaller than in the chief competitive countries.

Technical changes, e.g. chamber coke ovens and the basic process of steel making, undermined the relative advantage of Britain as compared with other producing areas, and British entrepreneurs had difficulty in adjusting themselves to the new conditions. They were not prepared to undertake the heavy capital expenditure required for mechanization on an adequate scale.

Apart from the technical advantages of large-scale production with the economies of heat and power attendant on continuous operation, there are advantages in administration and marketing, which this country did not fully exploit owing to its smaller undertakings. Moreover, the dominant position occupied by the merchant gave a distributive mechanism which became gradually less suited for marketing in comparison with the organized distribution adopted by foreign industries.

It may be concluded that the iron and steel industry shared in a common feature of lack of flexibility in production and marketing, disadvantages which it could have overcome; the extent and significance of this lag will be postponed for appraisal in a later chapter.

(c) Capital

1. Changes in Capital Supplies

The passing of the Limited Liability Consolidating Act in 1862 greatly increased the availability of capital for industry. From 1870 to 1913 British industry was not handicapped by difficulties in raising capital, although there was an outflow to high-yielding foreign investments. Even these, however, represented in real terms British exports going out to build up capital equipment abroad and meant, therefore, increased activity for home industry. Moreover, home industry in general, including the iron and steel industry, was in a sound dividend paying position. From 1870 to the end of the century borrowing got cheaper, but after 1900 it grew dearer up to the war in 1914. As the rate of interest depended on total savings in relation to the demand for loans, the rise meant that either less wealth was available for investment, or opportunities for investment were increasing faster than capital supplies, even when allowance has been made for changes in the value of money.

During the war interest rates rose and remained afterwards appreciably higher. Between 1918 and 1920 there was a good deal of capital expenditure in anticipation of a demand to make up for the assumed or real deficiencies of civil production during the war. The boom was, however, short-lived; the increased demand did not materialize and during the severe depression that followed there was little investment in capital goods requiring the products of the iron and steel industry. Prices fell and this made people prefer to hold their savings in a liquid form rather than to re-equip industry for which they could see no immediately profitable future. Industry was faced with the problem of excessive capitalization, due, in part, to the unduly high amounts paid for firms absorbed in combination schemes during the artificial boom, in part to the watering of capital. Owing to the fall in production the high capital charges on industry could not be met, or could be met only with difficulty.

In the iron and steel industry in particular, capitalization had been increased two and a half times in 1923 compared with 1913, and investment had taken place with little regard to development

policy as a whole. Moreover, in 1923 output was only 8 per cent greater than in 1913, against a capacity 70 per cent greater and a nominal capital 150 per cent greater. Dividends were lacking and it was difficult, if not impossible, to attract fresh capital for necessary developments.

By way of contrast, in the post-war years French and Belgian industries were largely rebuilt with reparation payments, and after the inflationary periods in those countries stabilization was effected at a much lower value of the currency units, thus reducing the burden of all fixed charges, as well as assisting exports. In Germany inflation was carried even further and a considerable amount of capital debt was written off.

After the war the U.S.A. had become the chief creditor nation and New York an increasingly important financial centre. Large quantities of American capital were exported to Europe during 1920–30, especially in the form of goods to re-equip the industries of Germany and of Central Europe or to establish new industries in the Succession States. These exports naturally greatly helped the American heavy industries.

In regard to banking, more was done in some foreign countries than here in supporting industry by long-term financing. In Germany, for example, banks used part of their resources to finance industrial and commercial enterprises, having at their command technical experts who could report on the probable success of technical or commercial ventures. The U.S.A. possessed the accumulation of capital necessary for financing industry on a large scale, but had no Central Bank system before the war, though local and State banks rendered assistance to industrialists through personal contact. The first help in the way of long-term financing was not given by British banks until the post-war dislocation and depression had indicated that some industries were quite unable to resuscitate their production owing to the collapse of their borrowing powers. The Bankers' Industrial Development Company was formed in 1930 by the Joint-Stock Banks and the Bank of England to finance rationalization schemes for industries as a whole or by regions. This was the surest way of providing the necessary capital at the time, and the cotton, coal, iron, steel and other industries availed themselves of it. Rationalization, however, as it was carried out, meant concentration of output on selected units and the elimination of redundant units. It was essentially a device to meet the terrible trade depression of 1931–33 and did not imply modernization and

re-equipment. It improved the financial position of particular firms and groups but it did not make any section of the iron and steel industry more productive or better able to meet overseas competition.

There is no evidence of any shortage of capital to British industries promising profitable investment, e.g. the electrical industry, but the iron and steel industry was an outstanding example of those which did not so promise, and in fact for which capital would not be forthcoming without re-organization or some special scheme.

2. Changes in Foreign Investment

In 1870, when this review opens, there was a considerable excess of imports into this country over visible exports. Including invisible exports—such as income from shipping, overseas investments, banking and merchanting—there was, however, a large export surplus. Against these "surplus exports" was set an invisible import—foreign loans. In other words, foreign countries were lent the funds to enable them to buy more from Britain than we purchased from them. It is immaterial to the present argument whether the export surplus made foreign loans possible or whether foreign loans led to an expansion in exports: the fact of the matter is that, before 1913, this country had a mounting annual total of foreign investments which were linked up with a large export trade in capital equipment mainly going towards the industrial development of other countries, e.g. for the construction of railways, harbours, factories, involving a demand for the products of our engineering industries, mainly iron and steel. The result was that the iron and steel industry benefited very considerably from the outflow of capital investment.

In the early seventies British foreign investments were being made at the rate of about £40 million per year. Before 1914 the excess of British exports over imports rose to about £100 million annually. Total British investments before 1914 are estimated as follows:

1872	£600 million	1902	£2,480 million
1882	£880 million	1913	£4,000 million
1893	£1,680 million		

In 1880 only about one-sixth of this outflow had been invested in the British Empire, but from then till 1914 colonial and dominion investments rose rapidly.

After the war the favourable balance on British trade decreased, and, in fact, in some years disappeared. Naturally enough the amount of capital invested abroad annually also fell considerably.

TABLE 14

AVERAGE ANNUAL OVERSEAS LENDING

1862–1872	£45 million
1872–1882	£30 million
1882–1893	£72·5 million
1893–1902	£90 million
1902–1914	£125 million
1914–1929	£10 million (net borrowing)

Capital migrates to where it is most wanted and will earn the highest interest. In the post-war period British financial interests were just as anxious to make profitable loans abroad as before, but as the favourable balance of payments had diminished they had themselves to borrow in order to do so. American financial interests, on the other hand, had large surpluses available and invested large sums in Europe and South America during the last decade of the period. This investment accompanied an increase in America's export surplus.

There are two sides to foreign investment: the financial, representing the placing of funds at the disposal of the borrower, and the real, in which the funds are used to buy goods. One does not, however, follow inevitably from the other. Having borrowed in one country the debtor may find it profitable to spend in another. This is just what happened in post-war Britain. This country did not apparently offer goods on sufficiently favourable terms although it was a good capital market. Having borrowed here, the debtor bought in America or in Europe, and the loan would have been taken out of this country in the form of gold had this country not in turn borrowed on short term. The consequent accumulation of short-term debt was a direct cause of the abandonment of the gold standard in 1931, when the lenders claimed repayment in gold which we were unable to satisfy. The foregoing illustrates, however, that the power to export is more significant than the power to lend, or, to put the point more precisely, a country must be a good exporter to be able to lend with impunity. The trouble with this country in the post-war years was not so much that it was ceasing to be a good lender but that it was ceasing to be a good exporter. The decline in foreign investment is, therefore, a symptom rather than a cause of a weakness in British export industries.

Another point is that an export trade in capital equipment must bear within itself the seeds of its own decline. The new countries

which British exports developed might ultimately have a sufficiency of railways and harbours and factories. The pace of capital goods exports cannot, therefore, hope to be maintained. Nevertheless, this does not fully explain why the fall in exports occurred in some forms of iron and steel and not in others, except in so far as the more highly finished forms (which suffered least) were more immediately consumable and not for constructional purposes. Other causes must, therefore, be sought to explain the changes in detail.

(*d*) Foreign Trade

1. Changes in Foreign Trade

Fig. IX (on logarithmic scale) shows the relative rates of increase of the foreign trade (exports plus imports) of the five countries studied. The absolute values are given in the Appendix, Table 105.

The total export trade of this country expanded in the pre-war period (1870–1913) at a rate which caused the value approximately to treble in sixty years. This growth may be divided into two at approximately the year 1897, the rate of increase in the latter period being the faster even when corrected for the upward turn in the price level which occurred in 1896. After the turn of the century there was, in fact, a large expansion of our staple trades, and our net exports more than doubled between 1898 and 1913. The export trade of Germany and the U.S.A. increased, however, faster than ours over the whole pre-war period, and before the war Germany had attained a greater total than this country. The rate of increase of French foreign trade was less than the British until about 1900, after which it increased slightly faster. Belgian foreign trade increased rapidly from 1865 to 1875. For the next thirty years it increased as fast as the British, but from 1895 to 1913 it rose faster than British trade, in fact, as fast as that of Germany or the U.S.A.

During the war the export trade of this country was not maintained at the 1913 level, but that of Germany, except with her allies, was cut off and devoted entirely to the prosecution of the war. French and Belgian productive resources were greatly impaired. On the other hand, the U.S.A., neutral countries and Japan, greatly increased the volume and value of their exports.

After 1920 there was a slow, absolute increase in British foreign trade, but a further relative decline and the U.S.A. surpassed our percentage of world trade.

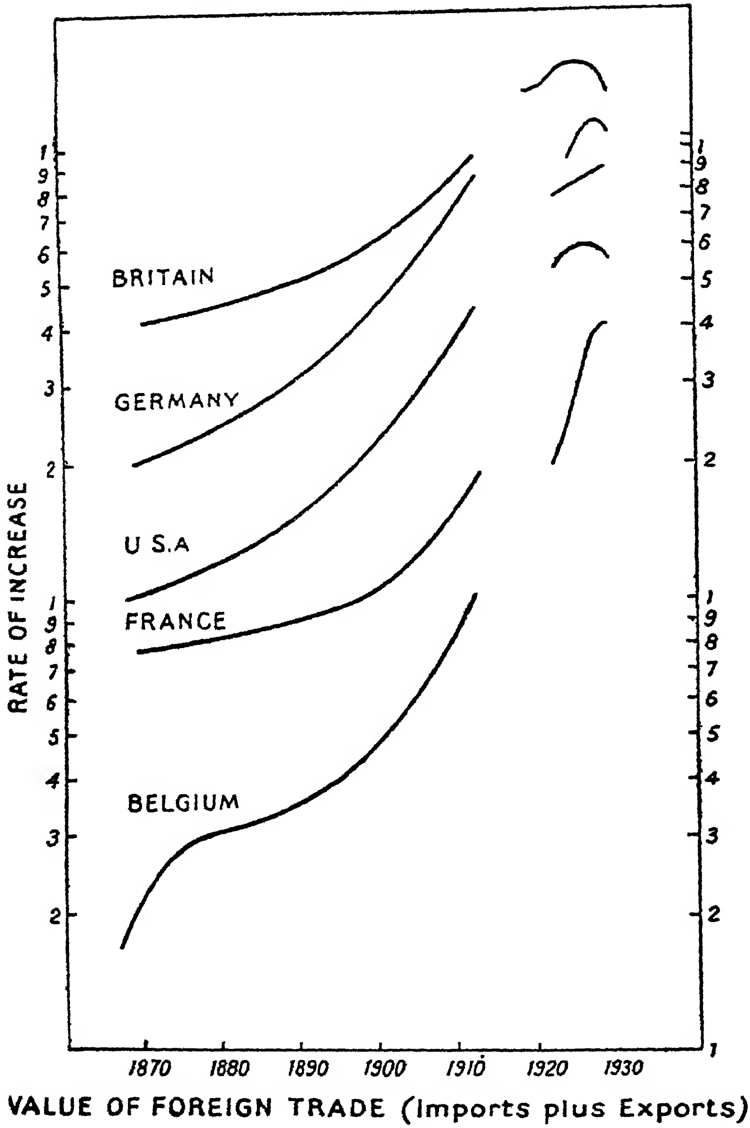

FIG. IX

PERCENTAGE OF WORLD TRADE

	1913		1927–29	
	Imports	*Exports*	*Imports*	*Exports*
United Kingdom	15·2	13·1	15·5	10·9
United States	8·4	12·6	12·2	15·5

French foreign trade was practically stationary. German foreign trade fluctuated but was relatively less above the 1913 level than that of other countries. Belgian foreign trade trebled in value. All these countries benefited from currency depreciation and import restrictions.

The interruption of foreign trade during the war was followed by a dislocation due to lack of access to established markets. Great Britain, having been first in the industrial field, was, before the war, in an established position and there was a keen demand for her products, but to recover this trade in the post-war period necessitated a displacement of products from other sources. The demand for British goods had become less elastic, and although some British products still sold on reputation, quality played a smaller and decreasing role in world markets. In engineering products there was a deflection of demand from the heavy long-life products, which we were best fitted to produce, to lighter and cheaper substitutes made abroad.

While British exports of iron and steel have shown features common to the development of total export trade, they have departed sufficiently in some respects from the general trend to merit special attention. Over the first forty years considered they did not increase as fast as the total figures. In post-war times they fell appreciably compared with 1913. While this is characteristic of the post-war depression of those industries in which this country had specialized, it was the exports of pig iron and crude steel which chiefly diminished; those of highly finished steel increased.

2. Changes in the Direction of Trade

(*i*) *Exports.*

From 1870 the relative importance of our trade with Europe diminished and after the war it fell off still further. Trade also decreased with South America, but trade with Africa, Asia and Australia increased. Trade with other parts of the Empire also rose. Thus we have:

	Exports to		*Imports from*	
	Foreign countries	*British Empire*	*Foreign countries*	*British Empire*
Year	*per cent*	*per cent*	*per cent*	*per cent*
1870	74	26	78	21
1925	61	39	70	30

Our Dominions endeavoured to increase their manufacturing industries as far as possible and to supply their own needs and our

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Our Dominions endeavoured to increase their manufacturing industries as far as possible and to supply their own needs and our

trade, in fact, developed principally with the less industrialized parts of the world.

The relative decline in British exports was a common feature of the decline of European trade, due in part to the increasing industrialization of the Far East and to the increase in exporting power of the U.S.A.

(ii) Imports.

From 1890 about one-third of the total imports of this country were raw materials and unmanufactured articles and there was no evidence of any appreciable change in the respective groups of imported commodities. Total imports about doubled between 1875 and 1913 but imports of iron and steel increased ten times over the same period, indicating in the opinion of some authorities the essential instability of our iron and steel industry. After the war imports of iron and steel increased further, attaining a maximum of 4½ million tons in 1927—a figure equivalent to our exports of these commodities by weight though not by value. Here, again, these imports increased more than the total imports, suggesting that some special factor was operative in the iron and steel industry.

3. Changes in Terms of Trade

Professor Bowley has shown* that by the end of the last century a given quantity of exports would buy more imported foodstuffs and raw materials than towards the beginning of the period under review. That is, the terms of trade had moved in favour of this country. We have seen that the proportion of our total imports covering foodstuffs and raw materials remained practically stationary over the period, and we were exchanging them for a relatively smaller quantity of exports, so that we had more to spend in other directions, either abroad or at home. It was noted above, moreover, that a change was occurring in our iron and steel export trade by which it was increasing with the less industrialized parts of the world.

After 1900 we could no longer dispose of our factory products for such large amounts of agricultural and raw materials. Other industrial countries were competing for the available supplies and we were obliged to offer a constantly increasing amount of factory goods to receive our essential supplies of foods and raw materials.

* *England's Foreign Trade in the 19th Century*, 1905.

The operation of the law of decreasing returns in raw material producing countries has been postponed in recent years by improved technique, which has, in fact, in many cases given increasing returns for the time being; in other words, subject to the influences of technical advances the volume of production has expanded without a rise in the cost of production. Before the war, except for short intervals, the general purchasing power of the raw material in producing countries went up. They were in a position to buy absolutely more but not necessarily proportionately more, as the selling price might fail to counterbalance the increase in efficiency. After the war conditions changed. During the period of high prices it was easy to obtain capital loans for expansion of operations; when the period of falling prices set in, the costs of production of raw materials did not fall proportionately—at least, this is true of some part of the last nine years of the period. So many raw material industries were un-prosperous, if not depressed, after 1921, that the terms of interchange moved to the disadvantage of raw material producing countries, and the slowing down of railway construction and similar work was a factor against the expansion of their purchases of iron and steel and machinery.

The fall in value of raw materials in terms of manufactured goods would result in these countries tending not to import so much proportionately to their increased output, and the growth of demand for iron and steel would be slackened even assuming they continued to buy the same proportion relative to their total expenditure. Owing to the slowing up of constructional work, however, there is reason to believe that the proportion would be less than before.

We may note, in fact, that world exports of iron and steel did not develop as fast as world production or world population. On the other hand, world trade in iron and steel did continue to increase absolutely after the war, so that the fall in British export trade was not in line with general development.

To sum up, in the post-war period the relative decline in British export trade as a whole indicates that certain factors were operating which were not peculiar to iron and steel and suggests the existence of limiting factors to development beyond the control of the industry. On the other hand, iron and steel exports suffered in comparison with exports as a whole, indicating that special factors were affecting the British iron and steel industry, which was experiencing competitive disadvantages peculiar to it and perhaps within its control.

(e) Changes in Price Level

Were movements in the general level of prices, a factor beyond the control of the industry, responsible for its relative decline? They can only be held to have been so in so far as the general level of British prices moved at variance with world prices or prices in competitive countries. Price movements peculiar to the iron and steel industry but, for some reason, beyond its control, may also be found accountable.

(i) The general course of prices over the period under review was as follows:

(1) a fall of wholesale and retail prices from 1873 to 1895,
(2) a considerable though less regular rise from 1896 to 1913,
(3) a rapid rise up to 1920 followed by a rapid and then slower fall.

In the first and second periods British and world general prices moved together, in the third period, after the last war, there were wide divergencies. The first period, of falling prices, was one in which British trade continued to expand and with it the iron and steel trade. Though prices fell, increased productivity lowered costs, and it was profitable to expand production. The rise in prices in the second period, which stimulated enterprise, was based on the gold discoveries and developments of the early nineties: for on the increased gold output the growing banking system built an inverted pyramid of bank credit. Real wages, which had increased in the first period, declined in this second period in this country, although in some foreign countries they continued to increase, suggesting a faster increase of productivity in those countries. In this period, as in the previous one, trade in general, and with it the iron and steel trade, expanded rapidly. So far as general price levels are concerned there do not seem, therefore, to be any factors at work before 1914 which can have affected the domestic industry in comparison with the industry abroad.

In the post-1920 period the long-term downward trend in prices ended to restrict enterprise and trade, and the general level of unemployment rose to over twice its pre-war norm. Most of the European countries had suffered from inflation during the war but, apart from the United Kingdom, they sought to stabilize their currencies at low levels which left their internal prices in line with or below the world level and the dollar level. France, for instance, enjoyed, as a result of currency devaluation, a level of export prices in 1929 below that of 1913, although the world level was far higher.

In comparison German prices were 32 per cent higher, American prices 25 per cent higher, and British prices 53 per cent higher.

In the United Kingdom the falling prices of the 1921 depression brought no export advantage, for currency depreciation on the Continent outweighed the effect and acted as a tariff on imports and a bounty on exports. The main setback to British export trade was, however, the return to the gold standard in 1925 at an overvalued currency level. The pound sterling which, as a result of the war, had depreciated in relation to the dollar was, as a matter of prestige, restored to parity with the dollar, although the British level of prices was some 10 per cent above the American and the world level. This overvaluation of sterling had two results, the first to cause a continuance of the post-1921 deflationary drive by the City in an attempt to get British prices down to the world level; a drive that did not succeed in equalizing British and world prices but did succeed in keeping British industry relatively depressed so that the boom of 1929 was, industrially, only a boom by reference to the depression that followed. The second effect of overvaluation was to act as a heavy drag on our export trade and to provide a bounty on imports. The rigidity of British costs caused them to remain high relatively to their competitors and the chronic unemployment demonstrated the disparity between prices and production costs.

Without suggesting that the whole difficulties of the export trade in the post-war decade, both general and in iron and steel, were due to currency factors, it is clear that a domestic price level 10 per cent above the world price level must have acted as a terrible handicap, enhancing the burden of the artificially expanded iron and steel trade in particular. The conclusion is that the overvaluation of sterling was a most potent factor in retarding the development of the iron and steel industry in the latter part of the post-war decade, particularly in the export trade, but in the domestic trade also, as this was placed at a relative disadvantage with competing imports. These disadvantages were not overcome till past the close of the period under review, when sterling was devalued in 1931 and a protective tariff was imposed in 1932. Whether the industry made the most of its newly won freedom is another matter.

(*ii*) We must now turn to an examination of movements in iron and steel prices in particular, inside the general price structure. In the first period, (1) of falling prices, expansion of the industry was not prevented owing to improvements in technique and transport which

constantly lowered costs. In the second period, (2) of rising prices, the law of decreasing returns had begun to operate as regards raw materials used by the iron and steel industry, so that their prices rose more than the average.

Comparing the trend of iron and steel prices in the different countries dealt with, up to 1896 the prices of pig iron fell slowly in England and Germany, rather faster in France and much faster in the U.S.A. The trend of bar steel prices fell less fast in England than in Germany. The purchasing power of pig iron, that is its price compared with the general price-list, rose in England and Germany but only very slightly in France; in the U.S.A. it fell fairly rapidly. The purchasing power of bar steel rose in England but fell in Germany. Thus there is evidence that the cheapening of iron and steel was occurring abroad relatively faster than here.

After the turning point in the course of general prices in 1896 the trend of pig iron prices was slightly upwards in England, also in France, and rather more steeply so in the U.S.A., while in Germany the trend was slightly downwards. The trend of bar steel prices was as follows: in England upwards, in Germany and the U.S.A. practically stationary. In this period the purchasing power of pig iron fell in the four countries mentioned but faster in France and Germany than in England and the U.S.A. The purchasing power of bar steel fell faster in Germany than in England. The stronger tendency to cheapening of German iron and steel must not be attributed so much to quality differences as to the lowering of production costs through technical and organizational improvements such as greater heat and by-product recovery, and technical integration of works. Relative price movements between the different countries, therefore, appear to have been a factor of improved technique and so, of course, *within* the control of the industry.

Price cycles showed as positive a correlation after the war as before, but after 1920 the price level of iron and steel was lowest in France and Belgium, whose prices governed the world market. In Britain iron and steel prices were lower than the general price level, largely because of over-capacity. The Balfour Committee (Survey of Metal Industries) found that the decline in price of iron and steel products relative to that of manufactured goods in general, was not accompanied by a corresponding reduction in cost.

We may say that price level trends throw some light on the position of the British iron and steel industry, viz. why German

trade expanded more rapidly before the war than ours did, and French and Belgian trade more rapidly after the war. They do not, however, give a complete picture of our relative decline in some iron and steel products and not others. International differences in price trends of iron and steel products are thought to be mainly controlled by production costs and policy in the industry rather than related to currency conditions and, in so far as they reflect production conditions, they are within the control of the industry.

(*f*) Tariffs

1. Tariff Changes

Was the development of the British industry retarded by:

(*a*) the absence of a tariff in this country;
(*b*) the presence of a tariff in competitive countries?

Free international trade is based on differences in comparative costs of production in the countries trading. Each country achieves the best advantage from production if it concentrates on those commodities it has a relative advantage in producing, irrespective of the absolute costs of production. It follows that it is not necessarily the country producing a commodity at the lowest cost that will export it. A country may, for instance, be beaten in its own market, in its own type of product, by goods from abroad, if it enjoys relative advantages in other products on which it pays to concentrate. Great Britain, an exporter of iron and steel, might well, therefore, find it advantageous to import crude steel and to export finished goods.

It is possible that iron and steel production in this country might have become more efficient, accompanied at the same time by an alteration in comparative costs which might retard or stop exchange of our iron and steel for given commodities of another country: that is, if *relative* prices are distorted a new direction is given to the mechanism of trade.

Tariffs may be applied in special cases, such as to build up an infant industry, to boost up home prices in order to allow cut export prices, or as protection against dumping in any of its various forms.

It is not true to say that theoretically tariffs are bad as they restrain mutually gainful international trade, although superficially this would appear to follow from the theory of comparative costs.

It depends on the circumstances. Where countries are employing their productive resources to the full it must clearly be to their mutual advantage to employ those resources in the manner that gives the maximum overall output, unless special considerations such as those of national security supervene. In fact, however, except during major wars, the leading industrial countries have never known full employment of their resources. The result is competition between the various producers to employ as much of their resources as possible, even though the sum total of wealth produced is lessened. It is each country's share of the total output that each country regards as important—not the total output itself. If the imposition of tariffs is necessary to maintain fuller national employment they will be imposed, although a country which has a relative advantage in production over its rivals does not need tariffs.

The advantages of free imports is shown by the fact that cheap Continental steel helped the expansion of some of our finishing trades, such as the tinplate, wire and tube manufactures, and engineering and shipbuilding industries. Obtaining semi-finished steel at world market prices more cheaply than their Continental competitors, and working it up in specialized finishing plants, British producers reduced their overall costs to a minimum and may have strengthened their hold on the finished steel markets of the world. This, however, is difficult to prove in view of the rebates granted on steel for export by the Continental countries. But the point was always raised when the leaders of the British industry requested protection by an import duty under the Safeguarding of Industries Act—they were asked to show that a duty, if conceded, would not injure other industries. The same point was raised in the reply of the Committee of Enquiry, appointed by the Government in 1930 to the request by the National Federation of Iron and Steel Manufacturers for protection of the home market as a bargaining weapon to obtain international co-operation in stabilizing world prices and as a means of negotiating entry to closed markets.

Moreover, if the low-price Continental crude steel had not been sold in this country it would have been sold elsewhere to compete with our finished products or the Continental countries would have felt more constrained to enter the finished steel market. The fact that our exports of finished products (tinplates and galvanized sheets) continued to increase whilst those of the cruder forms of steel diminished, showed an improved relative advantage in the former and a fall in relative advantage as regards the latter. The

cheap imports of crude steel were, certainly, a factor in the increase in relative advantage of fine sheet production.

The questions asked at the opening of this section may be answered briefly as follows:

(*a*) The absence of tariffs in this country tended to oblige the industry to develop on lines dictated by its protected competitors and to prevent the organization of the industry to use discriminatory prices to support exports. On the other hand, low home prices were an advantage to industries using the products of the iron and steel trades. British costs were higher, however, than in competitive countries except for highly finished products such as tinplates and special pig irons for which the demand was diminishing. In this country (which in 1870 carried on the greater part of the world's production of iron and steel) no protective tariff was ever needed on the grounds that iron and steel was an infant industry. Other countries at this time *may* have needed a tariff and in most cases thought they did.

In the appendix (Tables 106, 107) an outline is given of the growth of iron and steel tariffs in the countries with which comparison is made.

In short, a rapid growth of the industry occurred both in protected countries and in practically free trade countries like Belgium, and, moreover, before the last war our most progressive competitors, Germany and U.S.A., carried on a policy of tariff reduction in iron and steel products.

(*b*) The competitive power of foreign countries in world markets was not proportional to the height of the tariff, e.g. Belgium with a low tariff was at all times a strong competitor and Germany's competition increased as her degree of protection fell. In this last case it would be a truer clue to what was really happening to say that as Germany's competitive power increased her degree of protection became less necessary and was reduced.

The following shows the general progress of the industry under various degrees of protection.

Rapid expansion under declining protection ..	Germany and post-war France.
Comparatively stationary under protective conditions	pre-war France.
Rapid expansion under declining protection ..	U.S.A.
Slow expansion under practically free trade ..	pre-war Belgium.
Rapid expansion under practically free trade	post-war Belgium.
Slow expansion under free trade ..	pre-war United Kingdom.
Stationary or slow decline under free trade..	post war United Kingdom.

Obviously the effect of protection is not a clear-cut issue, but a complex one which may be modified or even overruled by other factors.

In world markets competition increased with (1) the necessity to find export outlets after industrial development had reached approximately the same level in the major countries, (2) the lowering of production costs in the home market and (3) the degree of organization of the home industry. The presence of tariffs in competitive countries certainly diminished our foreign trade—increased production overseas was at our expense—and the organization of the industry in these countries permitted a fuller export on the basis of discriminatory prices.

After protecting their home markets and organizing their industries the Continental cartels decided to increase their output, knowing that costs would fall per unit and the additional quantity could be sold abroad at low prices and yet leave their production profitable on the whole. Moreover, rationalization gave them advantages in the spread of knowledge of production methods and in the formation of optimum sized sales units.

The tariff history of iron and steel contains interesting features. Tariffs were first proposed for bargaining purposes in this country in the seventies. At that time discrimination was already practised by British iron makers both for exports and for internal competition which was intense about 1880. English railmakers also joined the International Railmakers' Association in its early stages. Overcapacity was inherent in the industry as capacity tended to be increased to cope with boom periods, while mean demand was far from running at this rate. Hence, in order to utilize capacity, when the home market became saturated, destructive dumping became almost inevitable for the industry and spasmodic dumping was in fact practised to obtain continuous working of plants. Before the Tariff Commission of 1930 British iron and steel makers referred to their selling part of their output below cost and that it paid them to take "unprofitable" business to bear part of their overheads.

For another reason British iron and steel makers would have welcomed a certain degree of protection: they needed to be assured of the home market before they could embark on large-scale operation. The reason that the home market was not secure was, however, related to the lack of properly integrated and well-balanced plants with modern mills for the large-scale production of semi-finished steel, the relative inefficiency of plant compared with the newer

industries abroad, the high cost of British labour and the obstacles to structural changes in the British industry.

A tariff would, of course, have increased the competitive strength of steel exports in general, although the clash with the exporters of highly finished products was always emphasized, and would have been the first step towards international price agreement. British industry as a whole, however, was, before the last war, dominated by the free trade tradition, for the good reason that its export supremacy was not yet endangered. British industry did not need tariffs—it was sufficiently master in its own market. Even in iron and steel, when, as late as 1925, the National Federation of Iron and Steel Manufacturers asked for the formation of a safeguarding committee, the re-rollers opposed the idea.

How far the position could have been improved by protecting our own market is problematical. At the beginning of the period there was no need to do so. In the decade before 1914 our exports were increasing at a fair rate, mainly in the finer or higher-grade products. Before the European War, however, it was felt, and after the war it was certain, that in the cruder forms of steel our unit costs were higher than abroad, the average size of our plant smaller and of greater age.

It is possible to argue that the reconstruction of the British industry could have been carried on behind a tariff barrier which would have enabled manufacturers to charge more in the home market, but it does not follow that any reconstruction would have resulted unless the industry had been assured of an increased market. Failing this the higher prices might only have gone into profits and been a burden on the finishing trades. The grave danger of a tariff is that it permits the entrenchment of inefficiency when prices are maintained to meet the needs of the highest cost producers. Rationalization should, therefore, come first; the 1930 Civil Research Committee said that a tariff without reorganization was dangerous and apparently hoped that rationalization would be forced on the industry to enable it to survive.

Protection of the British market might have resulted in a price level which permitted a more adequate allowance for depreciation and modernization of plant; it might have assisted or advanced organization of the industry in spite of the inherent individualistic trait amongst British manufacturers, but it is doubtful whether old plants would have been closed and replaced by new ones, erected on the most economic sites and large enough to take advantage

of the full economics of balanced large-scale production, although probably only a procedure as bold and far-seeing as this would have stopped the increasing imports. It must be borne in mind that our exports were increasingly becoming "transformed" goods and it was essential to buy the semi-finished materials at the lowest world market prices. If the finishing industries had had to pay more for their raw materials our exports would have suffered in value if not in quantity. One is led to the conclusion, therefore, that, in spite of the advantages of a safe home market, which would have encouraged investment in the industry, the lack of it was not the sole cause working adversely to our relative progress.

To turn to experience abroad, in the U.S.A. the tariff of 1873 was high specifically to guard against the entry of British iron. Here, of course, is the "infant industry" argument.

In Germany in the seventies, exports were being sold at prime cost (Eisen Enquete Kommission), and the duties of 1880 were admittedly devised with a view to raiding export markets. At this time French and Belgian firms were also charging discriminatory prices.

The American and German tariffs in the nineties undoubtedly contributed to the decline of British exports through "dumping," and here is certainly a factor beyond the control of the industry. After the turn of the century protection continued to increase and spread to such countries as Russia. In America export sales were being made below cost in 1903; in Germany the degree of discrimination varied with the urgency to export, being highest in depression years when the home market was reduced; in Belgium, in 1904, export prices were 5 to 10 frs. per ton lower than home prices. The policy continued in an intensified form after the war when, for instance, French and Belgian bars and plates were exported at as much as 30s. per ton below the home price. From 1924 onwards, when the mark was stabilized, German tariffs were unnecessary as regards competition from this country, except in the case of pig iron, yet the tariffs were maintained and the move towards syndication was made with the avowed intention of exercising price differentials.

2. Tariffs and Prices

In spite of tariffs in the U.S.A. and Germany and their absence in Great Britain, there was a strong consonance before the European War between the movements of prices of iron and steel products

in these countries. This is illustrated by the following figures showing the magnitude of price movements between 1900 and 1913:

	Mean Deviation %	
	Pig Iron	*Steel Bars*
U.S.A.	14·7	10·1
Germany	8·8	12·3
Great Britain	6·8	6·2

The smaller variation in this country was due to the better adjustment of production to consumption. After the war there was also a close influence of the inland markets of the iron-producing countries on each other.

Export necessity may be measured by: $\frac{\text{exports}}{\text{production}}$ or $\frac{\text{home demand}}{\text{capacity}}$.

Using the former ratio expressed as a percentage and comparing the pre-war and post-war period we have:

1913	*Pig Iron*	*Steel*
Belgium	0·7	62·5
France	2·1	11·0
Britain	9·2	52·0
Germany	4·1	29·0
U.S.A.	0·9	8·4

Belgian export prices led world, followed by Belgian home prices and then German export prices.

1925	*Pig Iron*	*Steel*
Belgium and Luxembourg	3·8	105
France	8·3	43
Britain	7·4	44
Germany	2·2	25
U.S.A.	0·1	36

Belgian and French export prices determined world prices.

Where the centre of gravity lies within the home market an improvement in the export market does not play an important role in improving home prices.

In rails, owing to the adherence of Great Britain to the International Rail Syndicate, there was no relation between English home prices and Continental export prices. In other products English prices had, as a point of reference, the prices f.o.b. Antwerp plus sea freight, land freight and insurance.

Among the disturbing conditions introduced by the war in 1914 were a redistribution of producing centres abroad under different political control, the separation of producing areas from pre-war markets and an increase in economic nationalism. Tariff barriers were raised, restrictive to foreign trade and leading to retaliatory measures. Some countries which were formerly good customers of Britain erected simultaneously steel plants and tariff barriers which were damaging to this country and could not be economically justified.

Summary

Summing up, it does not appear that tariffs are essential or even necessary for the maintenance of a prosperous iron and steel industry in this country. Apart from their being in general undesirable—except in so far as they are overridden by factors of national security or the interests of producers being more important than those of consumers—the facts show that our industry and export trade expanded before 1914, whilst the industry abroad was in general well protected. On the other hand, would it have expanded faster had it been protected by a tariff? It was clearly tending to become a finishing industry which might have been more profitable but again raised questions of security. After the war a new set of conditions intervened and it cannot be said that high tariffs were the cause of the fall in the British trade, as they should have affected the trade of other countries more than ours owing to the operation of the most favoured nation clause. The efficacy of this clause was, however, in danger of disappearing, and it does not take into account the discrimination in export prices adopted by the Continental industries. On the other hand, the conscious and deliberate economic nationalism of the post-war period emphasized our isolation in fiscal policy. Britain was exposed to the organized attacks of foreign industries, and considerations not having a purely economic basis indicated the necessity in the national interests of calling a halt to give time to look into the reasons for the decline in crude steel manufacture and to investigate the possibilities of negotiation with the increasingly highly organized foreign industries with regard to the sharing of markets.

It may be concluded, therefore, that whilst the imposition of tariffs abroad had a restrictive influence on our iron and steel exports, fiscal considerations have, however, not given a sufficient explanation of the trend of the industry.

(g) Conclusions

This chapter set out to examine whether the history of the iron and steel industry could have been otherwise than as described in the previous chapter. Its object was to discover whether there were limiting factors in the economic framework in which the industry had to operate that necessarily retarded its development in comparison with the industry in competitor countries. We conclude that there were certain factors adversely affecting the development in the industry but that others examined had no real significance.

In the first place it was clear that the later development of many overseas countries was bound to be felt in two ways: first, in their early stages of development they were markets for British exports; secondly, they ultimately ceased to be so and became finally competitors. So far as home markets were concerned the newcomers had to obtain their share, but this does not explain the relative decline in British export trade, for in the export markets all comers had equal opportunities. Further, we found that this country did not suffer from any lack of capital supplies, and if these did not flow into the iron and steel industry it was through lack of promise in that industry. Similarly with foreign investment no special factors operated to prevent the iron and steel industry from maintaining its hold on markets: if loans were reduced, one reason was that the industry was exporting less and thereby reducing the lendable surplus.

The over-valuation of sterling in the post-war decade was, on the other hand, a most important factor adversely affecting the industry. The same cannot be said of free trade policy—here tariffs would, after the turn of the century, have helped the industry, though not necessarily to the national advantage, but there were other and more important steps the industry could have taken to help itself.

In short, once allowances have been made for the inevitable effect of the growth of the other industrial countries, and this should not be under-estimated, apart from the evil effects of post-war currency over-valuation—and here the warning must be against over-estimation—the retardation in expansion of the industry at home and in the open competitive markets of the world must be laid at the door of the industry itself, and appears to have been largely due to its lack of flexibility in the face of changing world conditions.

CHAPTER III

Was Britain at a Natural Disadvantage as Regards Raw Materials?

(a) Introduction

A relative advantage in production costs may accrue to a country either from a difference in industrial phase or a difference in availability of natural resources. In 1870 the British iron and steel industry was advanced in phase compared with its competitors, but during the period under review it lost this advantage and began to lag in some respects. It is now necessary to investigate whether any change also occurred in the economic availability of raw materials acting to the relative disadvantage of the British iron and steel industry.

1. The Importance of Raw Materials

The importance of this enquiry lies in the fact that raw materials constitute from 75 to 85 per cent of the cost of pig iron production. Labour cost is a relatively small proportion of the total—less than 10 per cent (for example, 6 to 9 per cent in this country and 5 to 6 per cent in the U.S.A.). Maintenance, renewals and other furnace costs make up the balance exclusive of administrative and selling costs.

It is not possible to assess the relative importance of ore and coke as constituents of the raw-materials cost without specifying the grade of ore and the type of iron produced. Sometimes the cost of ore per ton of pig iron is more than that of the coke and sometimes the reverse. In Britain, for example, when making pig iron from native ores the coke costs about twice as much as the ore, but when using imported ore the latter costs nearly 50 per cent more than the coke. Moreover, the ratio of ore cost to coke cost may change for a given iron over a period. In the case of Bessemer iron, for example, the ore to coke ratio fell between pre-1914 and post-1918. The ore cost per ton of pig iron is, on the average, more in U.S.A. (Pittsburgh) and in Germany than the coke cost. but less in Bel-

gium and much less in France and Luxembourg. On the whole, the cost of coke per ton of iron shows less variation than the cost of ore. More ore is required than coke per ton of iron—approximately twice as much on an average—and this must, of course, be borne in mind when considering whether ore should be brought to coke or vice versa.

2. The Economic Availability of Raw Materials

In the above ratio of ore cost to coke cost, the cost of assembly at blast furnace has been taken into account. At first sight it would appear more economic to transport 1¼ tons of coke to 2½ tons of ore than vice versa, but as a matter of fact pig iron production is generally based on taking the ore to the coke. The Lake Superior ores are taken 1,000 miles to Pennsylvanian coke, half of the iron made in the United Kingdom is from Spanish or African ores, and, after the loss of Lorraine, Germany made the greater portion of her pig iron from Swedish or Spanish ores. The most notable exception, viz., location of an iron industry on the ore deposits, is, of course, in Lorraine—where basic pig iron was produced as cheaply as anywhere in the world.

The chief objection to the transport of coke is that its friability causes a loss every time it is handled. Whilst coke is itself sometimes imported, it is not necessary or essential to ship coke, in fact it is preferable to receive coal and carbonize it on the site, as the coke and gas are then available where required to give the economy of technical integration. There is a greater attraction for the iron-making industry to locate on coalfields than on ore deposits, but it is not essential for the industry to be located on either, as for example in the case of Belgium, which imports the bulk of its ore (from Luxembourg) and coal or coke (from Germany and the United Kingdom). There are, therefore, other factors in the location of a successful iron and steel industry than proximity to raw materials. The cost of pig iron production is made up of the cost of the assembled raw materials, of labour and of overhead charges; the ideal arrangement is, of course, to have blast furnaces on the site of ore and coal—i.e. cost of assembly negligible. The next most favourable condition is to have blast furnaces located on seaboard coal mines so that the ore may be water-borne. In the British iron and steel industry both the above conditions are found. When the price per ton of ore is less than half the price of coke it may be advantageous to take the coal to the ore. Moreover, a country having neither of the essential

materials may not be unfavourably situated if both ore and coal may be cheaply transported into it. It should be further remembered that two points in geographical proximity on land may be far apart from the point of view of economic assembly of raw materials and vice versa if water transport between the points is possible.

3. Importance of Haulage Distance

Britain has a natural advantage in shortness of hauls, due to reasonably close proximity of native ore and coal, and also possesses coal mines at seaboard to which rich foreign ores can be cheaply transported. British costs of assembly when using native ore were less than in Germany, where rich foreign ore was water-borne to the Ruhr coalfield; or than in Lorraine and Luxembourg, where coke had to be transported to the ore; or than in Belgium, to which both ore and coke were transported. They were considerably less than in Pittsburgh (U.S.A.), to which the ore had to be carried a distance of 1,000 miles. The average haul of raw materials to works was, in fact:

U.S.A.	750 miles
France	200 ,,
Belgium	160 ,,
Germany	150 ,,
Britain	30 ,,

On the other hand, the cost of assembly of materials per ton of iron made from imported ores was as much in Britain as in Belgium.

4. The Effect of Raw Material Ownership

The cost of production of pig iron is determined not only by the physical availability of raw material supplies but also by the question of ownership. Apart from the advantages of independence and the less likelihood of interruption of supplies, the most economic arrangement is for pig iron makers to control their coal and ore supplies. High capitalization is, however, required and the majority of pig iron making firms in this country were not large enough to own their ore supplies. Nevertheless, the advantages of the ownership of raw materials were early recognized and constituted an important factor in the trend towards integration which occurred abroad at the end of the last century and at home after the beginning of the present one. This trend was accelerated abroad either by a desire to escape domination by Cartels, as in Germany and France, or by an early recognition of the economic advantages accompanying

consolidations and large-scale production as in the U.S.A. (e.g. the combination of the Carnegie and Freck interests in 1892). When the United States Steel Corporation was formed in 1901, ore supplies were ensured by the inclusion of the Lake Superior Consolidated Iron Mines Company. In 1903 Jeans gave the following measure of the advantage of raw materials ownership in Germany:

Basic Iron

Cost in works with their own ore mines and cokeries and using hot metal ..	36s. 0d. per ton
Cost where ore and coke were bought ..	40s. 7d. ,,

He stated that the pig iron firms in Britain were pig iron makers only. On the other hand, these experienced little difficulty in obtaining ore or coal and a certain amount of price protection for non-integrated firms arose from the fact that under free trade conditions an upper limit to prices was decided by the cost of importing foreign supplies.

Whilst the wide distribution of natural resources in Britain did not favour combination, a movement towards integration can be clearly traced before 1914, and the advantages were so much appreciated that in 1917–18 pig iron manufacturers owned 72 per cent of their ore supply, 62 per cent of their coal and 55 per cent of their coke.

For those firms which were not large enough to own ore and mines, an alternative used on the Continent was for the Pig Iron Cartel to enter into an agreement with the Coal Syndicate and the Association of Ore Mines.

In Britain the question of control of foreign supplies was important due to the high cost per ton of iron in imported ores. About one-half of British pig iron was made from imported ores and the business of supplying these ores was in the hands of merchants. The Departmental Committee of the Iron and Steel Trades 1917 recommended the creation of a co-operative organization to import and distribute ores in Great Britain and to acquire ore properties abroad, but no action was taken. Some firms bought mines in Spain but purchasing associations were not much resorted to, owing to the drawback that members had to commit themselves over a term of years.

(*b*) Iron Ore

1. Reserves

Reserves of iron ore in the world are sufficient to supply its needs for many generations. They have been estimated (Committee on Industry and Trade—Survey of Metal Industries (1928)) as follows:

TABLE 15

IRON ORE RESERVES (ESTIMATED)

Country	Proved	Million tons Possible	Total	Total as Per cent of World Reserves	Approximate Iron Content per cent
U.S.A.	10,452	83,870	94,324	41·8	50–60
France	8,160	4,090	12,250	5·4	40
Great Britain	5,970	6,200	12,170	5·4	30–35
Germany	1,320	2,843	4,160	1·8	40
World	57,810	167,660	225,470	100	—

A large part of the above reserves is not, however, commercially available, but both the U.S.A. and Europe have resources to last one thousand years.

The reserves of the United Kingdom are also still large, though mainly of low iron content. They are constituted as follows:

	Million tons Actual	Probable	Possible	Total
Jurassic	1,212	2,177	420	3,774
Carboniferous	1,049	1,247	5,423	7,716
Bedded	45	—	—	—
Hematites	45	90	—	130
Other deposits	—	15	75	91
	2,306	3,529	5,918	11,711

There are thus about 12,000 million tons—sufficient for over one thousand years' requirements, or over several hundred years on proved reserves only. The deposits are not far from coal, or sea-board, or markets, but vary in economic availability. In particular the carboniferous deposits, forming the bulk, cannot much longer be economically worked.

The economic value of an iron ore deposit depends, in addition to its geographical position relative to points of consumption, on the cost of mining and on the character of the ore. The ideal mode of occurrence and metallurgical character of the ore are:

(1) Readily mined.
(2) Near to blast furnace sites.
(3) High iron content.
(4) Low moisture and impurities content.

The chief distinction in iron ores is between phosphoric and non-phosphoric categories. Up to about 1880 all steel was made by the acid process and only low phosphorus irons were used. In

Britain there were low phosphorus ores on the north-west coast and production had by that time increased to 2½ million tons per year. On the other hand, Germany, France and Belgium were deficient in non-phosphoric ores, and in the U.S.A., although the Lake Superior deposits contained a large quantity of low phosphorus ores, long distance transport to smelting site had to be developed to render them economically available.

The resources of Britain in non-phosphoric ores were, however, limited, and production decreased after 1882, making it necessary to import increasingly from Spanish, African and other non-phosphoric deposits.

The discovery of the basic steel-making process in 1879 caused revolutionary changes. Large ore deposits in Lorraine, Luxembourg and France became usable and the ore resources of the U.S.A. were considerably increased. It may be noted that in the latter part of the period, 85 per cent of the world output of iron ore was phosphoric.

2. Ore Production

The total production of iron ore by the countries compared is given in Table 16 and Fig. X.

TABLE 16

Production of Iron Ore, 1870–1930

Thousand tons

Year	*Great Britain*	*Germany and Luxembourg*	*France*	*Belgium*	*U.S.A.*	*World*
1870	14,371	3,839	2,614	654	3,032	—
1875	15,821	4,730	2,506	365	4,047	—
1880	18,026	7,239	2,874	254	7,120	—
1885	15,418	9,158	2,318	187	7,618	—
1890	13,781	11,406	3,472	187	16,036	—
1895	12,615	12,350	3,680	335	15,958	—
1900	14,028	18,984	5,448	259	27,553	—
1905	14,591	23,444	7,395	177	42,526	—
1910	15,226	28,710	14,606	123	56,890	128,000
1913	15,997	35,941	21,918	150	61,980	170,500
1920	12,706	6,362	13,921	17	67,604	104,000
1925	10,142	5,923	35,763	166	61,908	148,500
1930	11,627	5,648	47,696	—	58,409	173,000

It will be noted that up to about 1890 Britain was the largest producer of the five countries. She was then surpassed by the U.S.A.,

then by Germany and before 1913 by France. After 1918 the positions of France and Germany were, of course, reversed.

Over the whole period the output of British ores has fallen, whereas production in the U.S.A. and Western Europe has risen at an increasing rate.

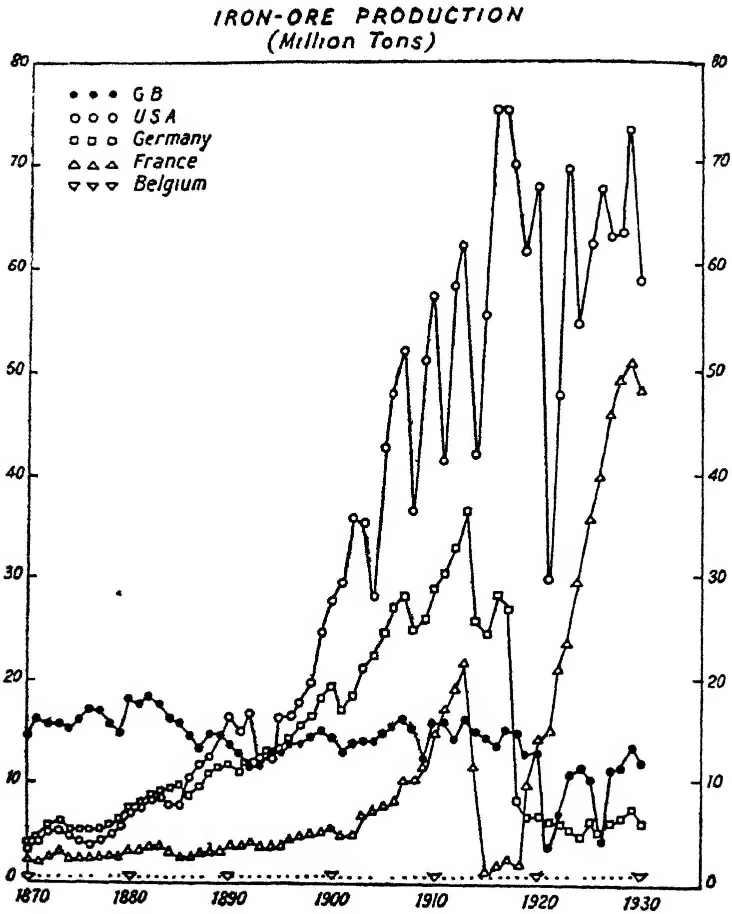

FIG. X

PRODUCTION OF IRON ORE, 1870–1930

Table 17 shows British iron ore output by types. Only the Jurassic (phosphoric) ores have increased, other types (West Coast Hematite and Coal Measures—non-phosphoric) have fallen off. In 1929 the output of Jurassic ores was 43 per cent of the total.

TABLE 17

GREAT BRITAIN

IRON ORE PRODUCTION BY TYPES

Thousand tons

Year	*Jurassic*	*West Coast Hematite*	*Coal Measures*
1873	7,500	2,250	4,995
1880	9,350	2,750	5,450
1890	8,750	2,350	2,400
1900	10,100	1,700	2,050
1910	11,700	1,750	1,700
1920	10,400	1,257	950
1930	10,000	1,134	350

Table 18 shows the course of iron ore production in British districts. Output in Lincolnshire and Northamptonshire increased; in Cleveland, Staffordshire and Scotland it fell.

TABLE 18

ORE PRODUCTION BY DISTRICTS (GREAT BRITAIN)

Thousand tons

Year	*Cleveland*	*Cumberland and Lancs*	*Lincs*	*Northants*	*Staffs*	*Scotland*
1870	4,072	2,093	248	800	1,360	3,490
1880	6,486	2,759	1,154	1,610	1,761	2,650
1890	5,617	2,399	1,052	1,278	1,224	990
1900	5,493	1,733	1,924	1,622	1,084	865
1910	6,160	1,743	2,128	2,649	913	650
1920	3,714	1,257	3,067	2,381	634	280
1930	2,173	1,134	3,358	2,410	316	20

3. THE COURSE OF IRON ORE PRICES

The prices paid for iron ores at smelting centres in Britain are compared in the following tables with those at smelting centres abroad.

At the beginning of the period, Cleveland ores were as cheap as any in the world (Lowthian Bell). All European ore prices were falling during the seventies, but choosing the end of the decade as a point of comparison, Cleveland cost about 3s. 6d. a ton compared with 4s. per ton for Briey ores in France, and 5s. for Brown Minette in Germany. In Belgium the average price paid for ore was about 6s. per ton.

At that time Cleveland ore was produced in far greater quantity

TABLE 19

GREAT BRITAIN: PRICE OF IRON ORE

Year	*Average Home Production*		*Average Imports*		*Cleveland*		*West Coast Hematite*		*Jurassic (Average)*		*Coal Measures*	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
1870	6	10	—		4	0	12	6	—		—	
1875	7	6	25	5	4	0	13	6	—		—	
1880	7	6	21	2	3	6	14	7	—		—	
1885	5	3	13	10	3	3	9	7	—		—	
1890	5	10	16	1	3	10	11	2	—		—	
1895	4	6	13	5	3	3	10	0	—		—	
1900	6	5	17	10	4	10	16	2	—		—	
1905	5	0	16	4	3	10	13	6	3	4	—	
1910	5	5	17	5	4	4	16	2	3	10	—	
1913	5	7	18	10	5	1	17	10	—		—	
1920	15	7	50	0	15	10	59	3	—		32	0
1925	5	8	21	10	6	3	19	10	3	10	13	2
1930	5	4	21	7	6	1	17	3	3	6	—	

TABLE 20

PRICE OF FOREIGN IRON ORES

	U S.A. (Lake Ports)				Germany				France		Belgium	
Year	Non-Bessemer		Bessemer		Roasted Spathic		Brown Minette		Average at Mine			
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
1870	37	6*	35	0†	19	0	6	3‡	3	5§	—	
1875	22	10	29	3	16	0	5	6	4	5	7	6
1880	33	3	38	5	15	0	4	6	4	2	5	10
1885	18	3	21	6	12	0	3	8	3	0	—	
1890	31	9	32	10	17	9	4	2	2	10	5	3
1895	7	10	9	1	10	6	3	4	2	8	—	
1900	16	8	18	9	19	0	4	1	3	1	—	
1905	12	6	14	6	14	0	3	6	3	3	—	
1910	16	6	19	6	15	6	3	11	3	9	8	6
1913	14	2	17	2	19	0	4	10	4	0	—	
1920	27	3	30	0	—		—		13	0	—	
1925	17	3	18	2	21	0	8	0	10	0	8	6
1930	18	6	19	5	20	0	6	0	5	0	—	

* Old Range. † New Range. Add about 5s. freight to Pittsburgh.
‡ Average official price. § *Statistique Annuelle.*

than any other British ore. The next in quantity was West Coast hematite, but its price was about four times as much per ton, while the price of Lake Superior ores (Old Range) was about half as much again as West Coast hematite.

Although the price of Cleveland ore slowly increased up to 1913, the average price of British native ores remained about 5s. per ton from 1885 to 1914. Over the same period the price of West Coast hematite ore had increased from 9s. to 18s. Prior to 1914 the price of Brown Minette in Germany and Briey ore in France was below 5s. per ton, and the average Belgian price 8s. 6d., but the price of calcined spathic ore in Germany (19s.) was comparable with that of West Coast hematite ore. In the U.S.A. the ore prices, after having reached a minimum at the end of the century, increased again in spite of the opening of the Messabi Range. In 1912 they varied from 11s. to 16s. at Lake Ports, according to grade, to which at least 5s. per ton must be added for freight to the Pittsburgh area.

After 1920 the cheapest ores in Britain were the Jurassic (about 4s. per ton), while Cleveland ores were above the average figure for native ores. Coal Measure ores, although of approximately the same iron content as the Jurassic, were about three times the average British price. West Coast hematite returned to the 1913 figure of 18s. In Germany Minette plus freight rose to nearly 9s. per ton, Swedish ore was imported at about 22s. and Rubio at about 20s. In Lorraine ore was charged to furnace at about 5s. per ton and the average price in Belgium was about 7s. In the U.S.A. iron ore at Lake Ports averaged about 18s., say 22s. with freight to Pittsburgh furnace. The average price of British native ores settled down before 1930 to approximately the same as in 1913, although the average price of imported ore had risen. Average prices of ore in France and Belgium also remained approximately the same. In the U.S.A. prices of Lake Superior ores at Lake Ports had risen 20 or 25 per cent. In Germany prices had also risen, Swedish and Spanish ores being imported in large quantities.

4. The Iron Content of Ores

The iron content of the principal ores of the world are given in the Appendix.

As an approximate figure, 30 per cent represents the Jurassic ores in the United Kingdom and the bulk of the ore in Lorraine, Saar and Luxembourg, 50 per cent represents West Coast hematites,

Lake Superior ores and Spanish Rubio ores, and the best Swedish ores contain 60 per cent iron or more.

5. Ore Used Per Ton of Iron Made

The average quantity of ore consumed per ton of pig iron made in the various countries shows a remarkable uniformity of between 2 and 2½ tons. Before 1914 France, Belgium, Britain and Germany were all using, on the average, about 2½ tons of ore to produce 1 ton of iron, and in the U.S.A. approximately 2 tons of ore were used. After 1918 the principal change was that Germany used richer ores and together with the U.S.A. utilized less than 2 tons of ore per ton of pig. Great Britain was again in about the same position as in 1913 with 2·4 tons of ore per ton of pig, and France and Belgium were on the average using a lower grade and therefore a larger quantity of ore than before. These figures are, however, too general to be of much service except as a guide or check.

6. Ore Transport Costs

The early development of the British iron and steel industry was associated with the close proximity of ironstone to coal, and the existence of convenient assembly points for export. This advantageous position was, however, offset by unfavourable transport costs. Over the whole period under review, railway freight charges were higher per ton mile in Britain than abroad.

The cost of Northamptonshire ores was trebled by transport to Middlesbrough (from 3s. 6d. to 10s. per ton), whilst the transport of Luxembourg ores to Belgium or of Lorraine ores to Germany only rather more than doubled the cost, in spite of the fact that the British haul was roughly one-quarter of the distance. The transport of Rubio ores to Middlesbrough also only doubled the ore cost.* Here is, in fact, one of the reasons why the cheap native British ores were not developed—Jurassic ironstone cannot bear heavy transport charges.

While in Britain the position was just allowed to drift, competitor countries reduced ton-mile rates by the construction of larger capacity ore-wagons, careful organization of traffic and the development, where possible, of water transport. The U.S.A. installed

* Freight charge per ton Rubio ore d/d Middlesbrough

1870	1880	1890	1900	1910	1913	1920	1925	1930
s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
10 0	7 0	6 3	6 9	4 6	5 3	25 0	6 6	6 6

24-ton trucks in 1880 and in 1890 employed 45-ton trucks with freight charges of 1s. 7d. per truck-mile. Compared with this, it should be noted that in 1886 West Coast ores were charged 4d. per ton-mile to Barrow. Although in 1900 a start was made with 20-ton wagons, they were the exception instead of the rule. Germany, in 1906, was using 15- to 20-ton trucks. She also developed canal traffic in a manner never attempted in Britain, using 300-ton barges for ore shipment.

Rates on Minette ore to Westphalia were gradually reduced, e.g.:

	s.	*d.*	
1881–93	7	11	per ton
1894	6	6	„ „
1901	5	4	„ „

One thousand ton shipments were made from Briey to Liège in 40-ton wagons for 5s. per ton or less.

It should be noted here that after the European War, in the difficult years 1920–30, British railway rates increased considerably more in proportion than our strongest competitors at the time—France and Belgium.

Other factors tending to reduce transport charges—mechanized handling and loading at mines, benefication of ores to diminish the transport of useless material and large-scale handling at discharge—were developed abroad to a much larger extent than in Britain. Although ores imported into Britain were increasing in price, there were no shipping improvements to offset this and the Balfour Committee (1928) pointed out that there were no good discharging facilities for large cargoes.

Greater improvements in shipping facilities and port equipment occurred on the Continent, e.g. at Antwerp and Rotterdam, and shipping freights were lower from Antwerp to India than from Britain to India.

7. Cost Per Ton of Iron in the Ore

The following table gives the value of British ores per ton of iron content. For native ores the average price per ton of iron charged to the blast furnaces was about 16s. before 1914 and settled down after 1920 to a figure not much higher (say 18s.).

Between 1885 and 1913 the average price per ton of imported ores rose from 13s. to 19s. and the average price per ton of iron

content was about 26s. before the war and increased to about 38s., when prices settled down in the twenties.

TABLE 21

VALUE PER TON OF IRON IN BRITISH ORES

Year	*Average Home-Production* s. d.	*Average Imports* s. d.	*Cleveland* s. d.	*West Coast Hematite* s. d.	*Jurassic Average* s. d.	*Coal Measures* s. d.
1900	19 6	37 6	—	—	—	—
1905	15 4	33 6	—	—	—	—
1910	15 4	36 6	14 6	—	—	—
1913	16 5	37 6	—	—	—	—
1920	50 0	100 0	17 0	—	—	—
1925	17 0	38 3	—	37 0	14 0	45 2
1930	17 2	39 0	21 9	32 7	12 6	—

The following table gives representative costs in 1913 of ore per ton of iron charged to blast furnace in the countries under comparison:

TABLE 22

COST PER TON OF ORE CHARGED TO FURNACE (1913)

Country	*Type of Ore*	*Cost of Ore per Ton* s. d	*Iron Content per cent*	*Cost of Ore per Ton of Iron* s. d.
United Kingdom	Native cheapest	4 0	30	13 0
" "	Native average	5 6	37	15 0
France	Basic	5 0	30	17 0
Germany	Minette	5 0	30	17 0
Belgium	Average	8 6	37	23 0
United Kingdom	Hematite	18 0	50	36 0
Germany	Roasted Spathic	17 0	50	34 0
U.S.A. (Pittsburgh)	Lake Superior	17 6	55	32 0

The above table may be compared with data relating to 1926, published by the American Metallurgist, Mr. P. Tyler (*Iron Trade Review*).

They agree sufficiently closely with the above estimate, but too much must not be read into either of the tables, for the burdens of blast furnaces are sometimes exceedingly complicated and rarely, indeed, is a single ore used. All that is claimed for the data is that they show comparative costs in a general way. They indicate that when using native phosphoric ores this country compared favourably in ore costs—although they were no cheaper than for certain regions in France, and even exceeded ore costs in Luxembourg.

TABLE 23

COST PER TON OF IRON CHARGED TO FURNACE (1926)

Country	*Cost per Ton Ore Plus Freight Charged to Blast Furnace* s. d.	*Iron Content*	*Cost of Ore per Ton Pig Iron* s. d.
U.S.A.: Lake Ports	17 6	51·5	32 3
Pittsburgh	22 0	51·5	40 8
Atlantic Ports	various	various	39 0
Great Britain: Best imported	20 0	50	38 3
Native ore	4 2	27	14 9
Germany: Swedish ore	22 7	60	35 9
Lorraine ore	10 6	32	31 3
France: Lorraine	4 9	32	14 0
Belgium	8 3	32	24 7

Prices of British ore imports since 1900 show that per ton of iron content they cost about twice as much, on the average, as home ores, and it should be noted that imported ores represent half the iron charged to British blast furnaces. On subtracting from the price of Rubio ore delivered at Tyneside the freight charge plus the cost of load and discharge, it is found that before 1914 the price at Bilbao rose from 7s. to 10s.; and fell, during 1920–30, again to 11s. or 12s. Thus the price at British furnaces was made up of one-half or more handling costs after mining, and the cost of mining was about double that of our Jurassic ores.

When using pure or high-grade ores the cost of ore per ton of iron was considerably higher than when using low-grade ores, but the cost of pig iron involves fuel costs and other items, and so whilst there is a prima facie case, the economy of low-grade ores is not definitely established without further analysis. Moreover, pure ores must be used for certain types of iron.

8. BRITISH ORE IMPORTS

In the sixties, South Wales had to obtain ores from other districts and started to use Spanish ores, which were found to be commercial; the North-East coast followed suit. From this time British iron makers became dependent on imported ores, and the increase in British imports from 1870 onwards is given in Table 24.

Britain was by no means exceptional in her use of increasing amounts of imported ore, as Continental producers were also doing the same (see Appendix on imports into foreign countries). The point arises, however, whether Britain did not import larger quan-

tities than was economically justifiable. While imports represented not more than one-half of the native ore production, owing to the higher grade of the imports, they contained as much iron as the larger quantity of native ores charged to blast furnace.

TABLE 24

BRITISH ORE PRODUCTION, IMPORTS AND TOTAL USED (THOUSAND TONS)

Year	*Production*	*Imports*	*Total Used*	*Pig Iron Made*
1870	14,371	208	14,163	5,963
1880	18,026	1,083	20,564	7,749
1890	13,781	4,432	18,205	7,904
1900	14,028	6,293	20,318	8,959
1910	15,226	7,019	22,238	10,012
1920	12,706	6,496	19,199	8,034
1930	11,627	4,088	18,517	6,192

Imported ores had to be used for hematite and other special irons, and before 1914 one-third or more of British production was hematite iron, which was exported in large quantities in addition to forge and foundry irons. There was, however, as we have noted above, a predilection towards acid steel making in Britain and an antipathy for basic steel making, although very large quantities of the latter were imported. This is all the more remarkable as it would have permitted the development of our native ores with their advantages in low cost. The Jurassic ores are mined by open working and there is no doubt that if the belt had been properly developed and handled on mechanized lines, the cost of ore winning would have been as low as anywhere in the world. Even so, the regions of Lincolnshire, Northants and Oxfordshire are the only districts in which production increased over the last half-century.

Million Tons of Ore

	1881	*1913*	*1928*
Northants	7·3	18·1	18·6
Lincs	5·9	16·5	28·6
Oxford	0·01	0·15	0·55

Lincolnshire, Northampton, Leicestershire, Rutland and Oxfordshire produced 16 per cent of the total in 1882, 41 per cent in 1913 and 65 per cent in 1929.

There was thus a shifting of ore winning to these districts, accompanied by a migration of pig iron making and later coke production, but it was unnecessarily delayed. It was not until 1927 that basic

steel production was started on the Northampton ore-field, although the burden was self-fluxing and the coke consumption low.

It may be noted that after 1918 exports of special pig irons fell off considerably and there was to this extent a diminished necessity to import hematite ores.

9. Gross Productivity of Ore Miners

The table below gives the yearly output per man employed in iron ore mining in Britain, the U.S.A., Germany and France. The ore mined per man employed was highest in Britain until the beginning of this century, when it was surpassed by the U.S.A., where mechanization was responsible for raising the per capita output to nearly double that of Britain. The output per man in Germany increased till by 1913 it was roughly the same as the British average. Production per man increased in Britain after 1920, due to the increasing exploitation of Jurassic ores worked by open-pit methods. The average output per man per shift doubled between 1910 and 1929. The increased productivity of French miners after the war over the British average was due to the accession of the more easily worked Lorraine deposits.

The order of gross productivity of miners in the various countries at the end of the period was (1) U.S.A., (2) France, (3) United Kingdom, (4) Germany. Further examination of the British figure indicates that from 1908 onwards the gross productivity of British miners decreased slightly, but after 1921 there was a marked upward trend, bringing the output per man higher than during the pre-war period. The productivity of the Cleveland miners fell off from the eighties and nineties, but in this century closely followed the average for the country up to 1921, though subsequently falling off. The average output of Jurassic ores per man was higher than the general average, the output being 4 to 5 tons per shift, which, with full mechanization, could have been increased to 15 tons per shift. For underground working, 2 tons per shift was produced. The productivity of the hematite miners was low, but shared in the general tendency to increase. In 1918 the West Coast hematite worked produced 16 cwt. per man per day. The production of ores from the Coal Measures was the lowest per man employed, and did not alter much throughout the period.

As for the position in Luxembourg, the average output in 1895 was 5 tons per man per day and in ten years it rose to 8 tons per man per day. In France in the Briey area 4½ tons per man per day

TABLE 25

ORE PRODUCTION PER MAN PER YEAR (TONS)

Year	Great Britain: Cleveland	Great Britain: West Coast Hematite	Great Britain: Coal Measures	Great Britain: Average	U.S.A.	Germany	France
1875	570	—	—	—	—	160	—
1880	800	—	—	460	250	220	350
1885	—	—	—	—	—	250	—
1890	—	—	—	400	—	300	—
1900	—	—	—	—	—	450	—
1910	690	125	—	670	1,000	550	—
1915	670	140	—	770	1,400	650	—
1920	470	100	150	540	1,450	230	750
1925	600	280	230	790*	1,800	340	1,120
1930	685	510	780	1,320*	—	—	—

* Average Jurassic 1,120 and 1,535.

was produced in 1913, falling to 3 tons during 1914–18, but subsequently rising above its pre-war level. In Lorraine 10 metric tons per day were produced by mechanical excavation. The labour cost was 4d. to 5d. per ton, and the total cost less than 4s. per ton.

10. ROYALTIES ON IRON ORES

In 1875 royalties on West Coast ores were 2s. per ton in Cumberland and 1s. per ton in Lancashire. In 1883 Lowthian Bell remarked that royalties pressed heavily on the iron makers, and gave the following comparison:

Cleveland	3s. 3d. (3s. 9d. in 1884)	Germany	6d.
Cumberland	6s. 3d.	France	8d.
Scotland	6d.	Belgium	1s. 3d. to 4s.

In 1893 J. D. Kendall stated that, owing to the peculiar character of British mineral laws, we worked at a great disadvantage compared with other nations. He quoted the findings of a Royal Commission on Royalties as follows:

	Term of years for which leases are generally granted	*Rents*
Cumberland and Furness	21 years	£100 to £2,000
Cleveland	42 ,,	£2 per acre
Lincoln	21–99 ,,	£1 to £12 per acre
Staffs	20–60 ,,	—
South Wales	42–99 ,,	—
Cornwall	21 ,,	£5 to £50

Royalties were given as follows:

Royalties	Wayleaves
Cumberland: usually ⅙th of selling price at pit mouth.	1d. to 2d. per ton underground. 1d. to 2d. per ton surface.

Selling Price	*Royalty*
9s. and under	1s.
9s. and 12s.	1s. 6d.
12s. and 15s.	⅙th of the selling.
15s. and 20s.	⅕th of the selling price.
20s. plus	¼th of the selling price.

Royalties	Wayleaves
Furness: similar sliding scale.	
Cleveland: 4d. to 1s. 2d. per ton average.	6d. to 1d. per ton.
Lincoln: 6d. to 1s.	8d.
Northants: 2½d. to 6d.	4d.
South Staffs: 9d. to 1s. 6d.	1s.
South Wales: 6d. to 1s.	8d.
Scotland (Bl. Bd.): 1s. to 1s. 6d.	1s. 6d. to 1d.

In 1904 the average British royalty was 9d. per ton.

Towards 1930 the royalties were about 9¼d. per ton, against 1¼d. to 2½d. in France, ¾d. to 1½d. in Belgium, 1¼d. to 3d. in Germany, 7d. to 1s. 8d. in U.S.A.

In the U.S.A. the royalties paid by the operating companies to face owners ranged from 10c. to more than $1 per ton. In 1923 an average of 41c. was paid on a tonnage of 44 millions.

In France all ironstone became the property of the State in 1810. Concessions are made at 8s. per sq. kilometre and 5 per cent on profits. If profits were 2s. per ton the royalty was 1¼d. per ton. In cases where the ore was sent to works and not sold on open market, the State found out the selling price and subtracted the cost of mining.

In Germany, also, royalties in the English sense were not paid, they depended on concessions and not on surface ownership.

It will be noted that on the Continent the system of land tenure was different to that in Britain, and in the U.S.A. royalties were not so high though taxes were the subject of complaint. In Britain royalty charges constituted an appreciable proportion of the selling price of ore, and the system of royalties and wayleaves was a hindrance to ore winning, particularly for low-grade ores. Even rich deposits could scarcely be worked profitably in times of dull trade, and as a result minerals were locked up. The sliding scale method called for revision, and mining needed to be more efficiently

organized, but the Mines Industry Act, 1926, was not made to apply to metalliferous mines.

11. Conclusions

It may be concluded that Britain was not handicapped in regard to the availability of iron ores at pig iron making sites, as the course of pig iron prices and the very large exports up to 1914 indicate the competitive strength of the British industry.

The price of native ores was not above that of corresponding foreign ores and Britain was in a favourable position for importing high-grade ores. The country was at a definite advantage as regards proximity of iron-making materials, but failed to exploit the position.

Improvements could have been made in the mining and transport of native ores and in the discharge of imported ores at British ports. Prohibitive rail rates, based on obsolete tariff schedules, were a hindrance to the development of our cheap native ores, and drastic reduction of delivery charges to blast furnaces should have been made.

The handling of the ore situation lacked foresight and vision; e.g. delay in mechanization of ore-winning methods, the small-scale transport of ore, and in the lag in integration of raw material ownership.

The most important hindrance was the amazing neglect of British basic ores, which were 2s. 6d. per ton closer to coal than Minette ores. The mixing of ores was neglected, although the advantages were known at the beginning of the period. British ores were adaptable to the Thomas process, but due to prejudice they were not exploited, although basic pig iron was imported from the Continent in addition to vast quantities of basic steel.

(c) Metallurgical Coke

1. Criterion of Fuel Cost in Iron Making

Fuel often represents the largest single constituent in the cost of iron and steel; cheap pig iron and the economic working of steel plants depend on cheap coke. Whilst in the present section the relative position of Britain in regard to the economic supply of coke to blast furnaces will be examined, this is only a part of the larger subject of fuel economy in iron and steel works. In converting iron ore into pig iron, and finally into finished steel, without unnecessary cooling, it may not be economical to strive for the lowest possible

coke consumption per ton of pig iron if the advantage obtained at later stages from the gas and other by-products more than compensates for the cost of additional coke.

The efficient utilization of surplus coke oven gas is an important opening for reducing the cost of coke and for improving fuel economy in the steel industry. Leaving aside, however, for the present, the credit balance of waste heat recovery, fuel costs in pig iron production depend on the cost of coke delivered to blast furnaces and the consumption of coke per ton of iron made. The product of these two factors may be taken as the criterion of efficiency in the use of fuel for iron making, but it is difficult to determine them with accuracy. The coke consumed per ton of iron depends on the type of ore, the quality of the coke, and, in fact, many other factors. The price of coke depends upon the cost of coal (when coal is dear, old and inefficient blast furnaces cannot be used), the coking costs, and the freight from coke ovens to blast furnaces. After indicating the amount of coke used for iron making, these three cost factors will be examined more closely.

2. Coke Consumed in Iron Making

The greater part of coke manufactured is consumed in blast furnaces, as indicated in the following data for Great Britain:

TABLE 26

COKE CONSUMED IN BLAST FURNACES IN GREAT BRITAIN

Year	*Produced at Ovens*	*Produced at Gas Works*	*Consumed in Blast Furnaces*	*Percentage Consumed in Blast Furnaces*
1908	11,200	7,300	9,700	87
1913	12,800	7,830	10,500	84
1920	12,600	8,300	10,000	79
1925	11,000	11,830	7,500	68
1930	11,500	12,300	7,500	65

In the U.S.A. over 80 per cent of oven coke was consumed in iron furnaces in 1913 and 77 per cent in 1928.

The total amount of coke produced in the countries under comparison is given in Table 27.

3. Constituents of Coke Cost

The factors affecting the price of coke are the cost of coal, operating costs, and the cost of transport.

TABLE 27

COKE PRODUCTION (000 TONS)

Year	Great Britain	Germany	France	Belgium	U.S.A.
1880	—	2,160	—	—	—
1885	—	—	—	—	—
1890	—	6,412	—	—	—
1895	—	8,200	—	1,750	—
1900	—	11,640	1,660	2,430	—
1905	—	16,500	1,870	2,530	32,230
1910	—	23,600	2,271	3,110	41,710
1913	20,730	34,630	2,940	3,520	46,300
1920	20,910	24,900	—	1,830	51,350
1925	22,838	26,810	3,064	4,110	51,270
1930	23,820	32,458	4,757*	5,951*	47,310

* 9,000 including production at metallurgical works, 1929.

(*a*) *The Cost of Coal.*

Up to the end of the nineteenth century Britain was the greatest coal producer in the world, but she has since then occupied second place. Of the other countries under comparison the U.S.A. and Germany have larger resources, but France and Belgium are badly off.

The cost of British coal per ton was the lowest in Europe before 1914, but it is doubtful if it has been on the average lower than in Germany since 1923. In the U.S.A. the price per ton has been considerably lower than in Britain since 1890. This is connected, among other factors, with the much higher productivity, i.e. output per man, of the American miners, and since 1910 the German workers have surpassed us in this respect. In Great Britain the productivity of coal miners decreased from 1880. Many of the best seams have been worked out and, with the exception of the South Yorkshire coalfield, coal has become, on the whole, more inaccessible. Moreover, mechanical improvements in coal winning and the application of electric power have not progressed as far as in some competitive countries.

It may therefore be stated that after 1918 the material advantages possessed by Britain in coal supplies definitely declined.

(*b*) *Operating Costs.*

Operating costs are affected not only by the type and design of oven, but by the preparation of the coal and by coking practice.

When the period under review opened metallurgical coke was made in this country in beehive ovens, although chamber ovens were in use on the Continent. In the eighties the use of chamber ovens in Britain was retarded by Sir Lowthian Bell's pronouncement against them, but owing to the improvements worked out in Germany and Belgium, experiments were continued, and after the turn of the century, development of chamber and by-product ovens was more rapid. The following table shows how the number of by-product ovens increased after 1900:

TABLE 28

COKE—NUMBER OF BY-PRODUCT OVENS

(R. A. Mott, Sheffield University)

Year	*Great Britain*	*U.S.A.*	*Germany*	*France*
1900	—	1,200	3,700	—
1905	2,600	3,100	10,500	—
1910	4,800	4,000	16,300	1,800
1913	6,000	5,500	22,700	2,700
1920	9,000	10,800	18,300	1,500
1925	8,000	11,300	16,800	3,600
1930	7,215	—	—	—

The big change-over from beehive to by-product ovens occurred in Britain in the decade 1908–18, somewhat earlier on the Continent, and later in the U.S.A., as shown by the following table of the percentage of coke made in beehive ovens:

TABLE 29

COKE—PERCENTAGE MADE IN BEEHIVE OVENS

Year	*Great Britain*	*U.S.A.*	*Germany*	*France*
1880	100	100	100	—
1890	93	100	—	—
1900	80	95	—	—
1905	73	89	—	—
1910	57	83	18	—
1913	36	72	11	23
1920	15	40	—	10
1925	8	22	—	—
1930	2	6	—	—

The dates at which the production of beehive coke fell below ten per cent were approximately as follows:

Germany	1914
France	1920
United Kingdom	1923
U.S.A.	1928

The advantages of beehives were low capital cost and ease of starting to meet sudden demand. Whilst beehive coke has long been claimed in some quarters as superior, it is of course dearer as there is no by-product recovery.

By-product ovens may be of three types—waste heat, recuperative or regenerative. In the first type, which formed the majority in Britain, the surplus of gas in only one-fifth to one-sixth of that of the regenerative type.

The gas surplus of regenerative ovens was on the average 10,000 c. ft. per ton of coke of value 5s. 5d. to 7s. 1d. The maximum possible was 17,000 c. ft. of value 9s. 3d. to 12s. It must be realized, however, that the market in Britain for by-products was not a good one, although some official scheme for the disposal of all by-products could have been organized.

In 1914 Britain did not appear to be greatly behind the Continent as regards output per by-product oven, but technical development was allowed to lag, particularly relative to the U.S.A., where developments occurred in oven size, the use of narrower ovens and of silica bricks, which greatly reduced the coking time and increased the oven throughput. Coking practice in Britain in 1920–30 was said to be in the same position as on the Continent before 1914. The modernization of plant in Britain was in many instances impracticable during 1920–30, due to difficulties in raising capital and the fact that a market could not be found for coke oven gas. The coking industry in Britain comprised a large number of small plants, many not carbonizing more than 100 to 200 tons per day. Large modern central by-product coking plants carbonizing the coal output of a number of collieries, at a rate per battery of not less than 2,000 tons per day (the average in Britain was 1,300 tons in 1920–30) would have reduced the cost of coke about 5s. per ton.

The capital construction cost of coke ovens was £2 to £3 per ton year, so that a 500,000-ton plant would have cost £1,000,000. It will be seen that the amortization charges would have been heavy, but the economy of large plants had already been proved.

On the Continent large sums were spent after 1918 in building centrally placed coke oven batteries, the surplus gas being sold to towns by means of long-distance mains, and the credits obtained, together with the low labour charges, reduced the cost of the coke appreciably.

The British coking industry was not on the average unfavourably placed due to the plentiful supplies of cheap coal near iron-making

centres, but could have been more efficient and have reduced coking costs in the following directions:

(a) The average age of ovens was high and they were badly equipped The majority dated from 1900–14 and many were built last century.
(b) The average output small. Even in 1929 the latter was 175 tons p.a. or 3 to 4 tons per week.
(c) The number of installations was excessive. In 1929 there were 154 different batteries of 100,000 tons annual capacity compared with over 500,000 tons as an average per year in U.S.A. and Germany. At Magnetogorsk a plant was constructed of 5,000,000 tons per annum.
(d) The percentage of regenerative ovens was too low. In 1930 nearly 50 per cent of the total capacity of by-product ovens consisted of waste heat installations.
(e) The cokeries were not well situated from a geographical point of view. Although in 1928 54 per cent of the total coke output was made by iron and steel companies, much was made at collieries mainly as an outlet for coal and the coke oven gas wasted. The coke ovens should have been centralized with reference to blast furnaces and steel works.
(f) There was no general marketing scheme for blast furnace coke.
(g) The disposal of by-products was not efficiently realized.
(h) The coke ovens were not heated (omitting exceptions) by blast furnace gases which would have permitted the richer coke oven gas to be used in steel plants.

(c) *Transport Costs.*

Freight charge to furnace may be an important factor in fuel costs, rail freight on British coke representing, on the average, 20 per cent on the delivered price.

It has always been appreciated that coke ovens should be near the iron works, so that sufficient gas should be available for subsequent operations in steel works. Heating the coke ovens with blast furnace gas and using the richer coke oven gas in steel plants results in considerable economies. From this point of view coal should be moved from collieries to ovens for coking, but coke made at pit head and railed to blast furnaces gives a 30 per cent saving in freight as compared with railing the coal. On the other hand, each time coke is handled its efficiency is reduced 2 per cent. Considerable quantities of coke are, however, moved particularly from Durham and Yorkshire which have always produced a surplus. In 1920–30 other districts also increased their domestic supplies.

On the whole, British hauls of coke are short and the freight addition to cost was as low as in any country, with the possible exception of parts of Germany. Hauls in France, Belgium and Luxembourg were in comparison long and transport cost constituted

a considerable proportion of delivered price. In the U.S.A. there were long hauls to furnace which counterbalanced the low price of coke at oven.

Britain was favourably situated, therefore, in regard to coke assembly cost but, as will be brought out in more detail in the next chapter, rail freights were comparatively high in comparison with charges in foreign countries.

4. The Course of Coke Prices

The prices of coke in the countries under comparison are given in Table 30. The figures relate to blast furnace coke, foundry coke being somewhat dearer. .

In spite of well-marked cycles the trend of the price of coke was upwards throughout the period; the same trend is observed in all countries since 1880, although the slopes of the curves differ. The British figures refer to coke at Middlesbrough and the average for the country, though freight charges may add 2s. or even 4s. per ton.

In Germany the figures are an average for the Ruhr district. After 1870 the prices were, on the whole, somewhat lower in Germany than in this country, and the same held good after 1923.

It is difficult to state an average price of coke in France as so much is imported. There are doubts if it was adequately recorded before the war. On the whole, however, France paid more for her coke than any other country.

For Belgium, official figures are available. Whilst at the beginning of the period prices were not above those in this country, they were at a somewhat higher level immediately pre-war times and also in the decade 1920–30.

The U.S.A. occupied a special position. The price of coke at ovens was considerably lower than in this country, but owing to longer haulage distances the advantage in price compared with Britain was counteracted and in some localities lost altogether.

5. Coke Consumption Per Ton of Pig Iron

Economy in coke consumption was studied by Sir Lowthian Bell in 1868–72. In the latter year the furnaces at his Clarence Works were consuming only 22·4 cwt. of coke per ton of iron made from Cleveland ores. During the eighties Bell reached the low limit of 20·5 cwt. of coke per ton. This must be taken, however, as an isolated effort for no extensive continuous experimental work was carried out in Britain. though the capital for it was not lacking.

TABLE 30

Coke Prices (per ton) at Ovens (1870–1930)

	Great Britain		Germany Average	France Average	Belgium Average	USA	
	Middlesbrough	Average				Average	Pittsburgh
1870	10/–	—	14/–	16/–	—	—	—
1875	17/6	—	14/6	28/6	14/6 – 15/–	9/6	10/–
1880	12/6	12/6	9/–	15/6	14/–	8/3	9/3
1885	—	—	8/–	15/6	11/–	6/3	6/3
1890	14/6	14/6	20/–	27/6	18/6	8/3	8/3
1895	12/– – 12/6	11/10	11/–	15/–	11/– – 15/6	6/–	6/–
1900	25/6 – 26/2	25/4	20/6	27/6	21/6	9/3	10/–
1905	15/– – 15/3	14/3	15/–	15/6	15/– – 15/6	9/6	11/–
1910	17/–	17/–	14/3 – 14/6	18/– – 20/6	16/6	8/–	10/–
1913	21/–	18/6	17/6	23/-	22/–	10/–	—
1915	19/6 – 26/–	—	16/–	—	21/6	—	10/3
1920	62/6	—	—	61/– – 65/–	—	39/–	39/–
1925	22/–	—	21/– – 24/–	27/– – 28/–	25/– – 26/–	15/6	21/–
1930	20/–	—	17/– – 20/–	23/– – 24/–	23/– – 27/-	14/–	20/ -
Sources	Sir L. Bell, Weeks, Hatch *Iron and Steel Trade Review*	Harbord, Iron and Steel Institute	Jungst, Sir L. Bell, *Stahl und Eisen*	L'Usine, *Annuaire Statistique*	Sir L. Bell, Ministere de l'Industrie Belge	U.S. Department of Commerce	American Iron and Steel Institute, Bureau of Mines

More attention was given to the subject in other countries, e.g. the German Warmestelle were scientifically investigating coke consumption before the formation of the Fuel Committee of the National Federation of Iron and Steel Manufacturers.

The comparison of the coke consumption per ton of iron in the various countries presents some difficulties. In the first place the total consumption of fuel in the blast furnaces of some countries has not been recorded except in a few years. Even if a comparison is made of the average consumption of coke per ton of pig iron, it is difficult to give it any precise meaning as it does not represent any specific practical conditions. Good practice in one locality may be bad economy in another—much depends on the chemical and physical nature of the ores and coke, the size and the rate of driving of the blast furnace and the quantity of special irons made. The following data must, therefore, be taken rather as a guide to the position.

TABLE 31

COKE CONSUMPTION PER TON OF PIG IRON (CWT.)

	Great Britain		*U.S.A.*	*Germany*	*France*	*Belgium*
Year	*Coal*	*Coke*	*Coke*	*Coke*	*Coke*	*Coke*
1875	49·5	—	—	—	—	—
1880	44·0	—	—	—	—	—
1890	41·0	—	—	—	—	—
1900	41·5	—	—	—	—	—
1910	41·0	25·0	—	—	—	—
1913	41·5	25·0	21·8	—	—	—
1920	44·5	28·5	20·5	22·5	28·5	—
1925	40·0	25·8	19·2	21 0	25·0	—
1930	37·7	24·0	18·4	—	—	21·0

The quantity of coal consumed in the production of pig iron calculated by the Fuel Department of the National Federation of Iron and Steel Manufacturers, after falling during the seventies, remained at a level of about 2 tons per ton of iron up to 1914, when it increased but subsequently fell again to approximately the same figure. The coal consumption has to be converted into coke tonnage on the estimated figure for the yield of coke,* of

* THE YIELD OF COKE PER TON OF COAL.—The yield of coke per ton of coal was 65 per cent in the Cleveland area in 1883, but it is doubtful if the average for Britain attained this figure till 1920–30. During the war years, 1914–18, it was considerably lower. The yield of coke in Belgium, Germany and France was consistently higher throughout the whole period under review. The fact that during 1920–30 it approached 80 per cent, whilst in Britain and the U.S.A. the average was about 66 per cent was due to the coal in the latter countries being higher in volatiles and the use of a much larger number of beehives than on the Continent.

which an international comparison is given in the following table:

TABLE 32

YIELD OF COKE PER TON OF COAL (PER CENT)

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1880	—	—	60	—	63
1890	—	70	—	73	64
1900	—	—	66	75	64
1910	60	74	76	—	66
1913	60	78	76	77	67
1920	69	80	—	—	68
1925	69	79	77	78	69
1930	70	—	—	—	—

The average consumption of coke in Britain may be taken as 25 cwt. over the period. The quantity might have been expected to decrease owing to increased efficiency of coke oven practice, but in the early part of the period the best seams of coal were being used, and the coke was larger and of a high degree of purity. Commenting in 1921 on the consumption of coke Stead (Presidential Address, Iron and Steel Institute) attributed considerable importance to imperfect coal washing. The coke consumption was highest in those districts where the coal is of poor coking quality, the ores lean and the quantity of flux also large. There was no correlation, however, between ore and coke consumption. Increases in coke consumption occurred when prices rose, showing a fall in quality, and decreases when prices fell, showing a rise in quality.

As an example of the effect of the type of ore used, however, the following figures were given by the Fuel Economy Committee of the British Association in 1916.

Ore Smelted	*Cwt. of Coke per Ton of Iron (average)*
Hematite	21·33
Cleveland	23·33
Midland	26·0
Lincolnshire	33·0

The coke requirements for the different types of pig iron may be taken as follows: hematite, 20·6 cwt.; basic, 26·8 cwt.; forge and foundry, 26·4 cwt.* The relatively high coke consumption in this country was associated with the small average size and low rate of

* Variations in consumption of individual furnaces are well illustrated in two papers by E. C. Evans of the N.F.I.S.M. in the *Journal of the Iron and Steel Institute*, 1928 and 1931.

driving of our blast furnaces, and the high proportion of special irons made, as well as some factors connected with the coke itself.*

In spite of the complexity of the subject, it may be said, however, that on the average coke consumption per ton of iron made was higher in Britain than in the countries under examination with the exception of France, and whilst the technical aspects of iron making were of importance, there was obviously considerable scope for improvement in the consumption and, therefore, in the cost of coke.

6. Cost Per Ton of Iron

The following figures on the constituent costs of pig iron making were given by Sir Lowthian Bell in 1903–4.

	Cleveland Foundry		*West Coast Hematite*	
	s.	*d.*	*s.*	*d.*
Ore	16	2	25	10
Coke	16	8	21	4
Limestone	1	6	1	4
Wages	3	10	4	0
Brick, clay, etc.	0	9	0	8
Fixed charges	2	4	2	5
Stores	0	9	0	7
	42	0	56	2

These costs may be compared with figures approximately ten and twenty years later, but great accuracy must not be expected as they are average figures.

The cost of materials per ton of pig iron in 1926 were given by the same authority (Table 34).

In Britain the coke cost when using native ores (though these were rarely used alone) was higher than for imported ones, which balances some but not all of the advantages in on-costs. On the whole,

* Uniformity of Coke Supplies.—A factor of considerable importance in the maintenance of low fuel costs in blast furnace work is uniformity in coke quality. It is more economical to use coke of a moderate quality varying within small limits than a mixed supply which is good and bad. A clean and uniform coke of high strength and reactivity is only obtained if the coal is cleaned and blended and the best methods of carbonization and quenching employed. Care must also be given to uniformity in size and the absence of breeze and dust. In Germany the coals were friable and the smalls in a large proportion, so special attention has been given to the above considerations. Britain had good coking coal and could produce coke as good as anywhere in the world, but generally speaking the grading and blending of coal, scientific practice and the regularity of coke left something to be desired. Practice varied considerably, but there was scope for reduction of this important item in the cost of pig iron. The absence of any specification was also a handicap.

TABLE 33

PIG IRON COSTS 1910–13 AND 1923 (P. M. Tyler, *Iron Age*)

	U.S.A.		Great Britain		Lorraine		Belgium	
	Acid	Bessemer	Acid	Bessemer	Basic	Bessemer	Basic	Bessemer
	1910	1923	1912	1923	1911	1923	1910	1923
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Ore	31 3	40 0	39 0	41 0	11 5	9 4	24 3	18 0
Coke	17 0	43 9	18 4	28 8	23 2	37 0	22 2	42 0
Limestone	1 8	5 2	1 8	0 5	—	—	—	—
Labour	2 9	7 3	4 2	7 3	0 7½	6 3	2 9	4 2
Other costs	6 3	8 0	3 7	7 3	0 7½	3 4	0 7½	4 2
Total	58 11	104 2	66 9	84 7	35 10	55 11	49 9½	68 4

however, the average coke costs were higher than for the greater part of the iron production of Germany and the States.

The lowest coke costs were attained in the U.S.A. under the most favourable conditions, i.e. in districts not far from Connellsville ovens. In other parts of the country—Chicago, Philadelphia, St. Louis—the price of coke was considerably higher, and other iron-making centres than that referred to in the table would not have an advantage over English coke costs in iron making.

There was every indication that in Germany the lowest costs in Europe were attained per ton of iron made. This appears true both before and after the 1914–18 war, in spite of the radical change in the ore situation.

Britain was, however, at a considerable advantage compared with France and Belgium in fuel costs. The chief reason was the large component of the total cost represented by transport. Before 1914 France imported nearly three million tons of coke a year and before 1930 over five million tons. For Belgium the corresponding figures were approximately one million and three million tons.

The greater part of this coke came from Germany, of which the exports were about six million tons per annum before the European War and rose to nearly nine million tons before 1930. Britain did not export relatively large quantities of metallurgical coke—about one million tons per annum before 1914—but there was a steady upward trend (Table 35).

TABLE 34

PIG IRON COSTS, 1926

	U.S.A.			Great Britain		Belgium	France		Germany (Ruhr)	
	Lake Ports	Pittsburgh	Atlantic Ports	Imported	Native		Lorraine	Luxembourg	Swedish	Lorraine
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Per ton ore plus freight	17 8	22 4	various	20 5	4 2	6 3	4 10	3 2	22 10	10 7
Iron content	51·5 %	51·5 %	various	50 %	27 %	32 %	32 %	30 %	60 %	32 %
Ore per ton of pig iron	12 8	41 3	39 7	38 10	14 8	25 0	14 4	10 0	36 2	31 7
Coke per ton of pig	28 1	16 8	33 3	24 0	33 2	33 3	37 6	25 0	19 2	25 0
Flux	2 1	2 6	2 6	2 6	0 10	—	—	—	—	—
Total cost	63 0	60 6	75 6	65 5	48 10	58 8	51 8	45 0	52 3	51 9

Assembly costs per ton of pig iron at the same time were given as:

	U.S.A.	Great Britain		Belgium	France		Germany (Ruhr)
	Pittsburgh	Imported	Native		Lorraine	Luxembourg	Swedish Ore
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Freight on ore	23 0	13 9	3 1	11 4	2 5	2 4	8 9
Freight on coke	5 5	2 4	4 2	4 2	13 0	12 6	1 8
Total (including limestone)	30 5	16 8	8 4	16 8	15 5	15 2	10 10

Adding the freight on coke to the cost of materials we obtain:
U.S.A. (Pittsburgh) 65s. 11d. France (Lorraine) 64s. 8d. Luxembourg 57s. 6d. Germany (Swedish ore) 53s. 11d. Great Britain (Imported ore) 67s. 9d. Great Britain (Native ore) 53s. Belgium 62s. 10d.

TABLE 35

EXPORTS OF COKE (000 TONS) (Approximate only)

Year	*Britain*	*Germany*	*U.S.A.*
1880	—	300	—
1890	100	1,000	—
1900	500	2.200	370
1910	1,000	4,100	1,000
1913	1,150	6,400	1,000
1920	1,700	1,000	800
1925	2,200	3,750	950
1930	2,500	10,000	—

IMPORTS OF COKE (000 TONS) (Approximate only)

Year	*France*	*Belgium*	*Germany*
1880	950	50	200
1890	1,250	—	350
1900	1,550	—	500
1910	2,250	—	600
1913	3,050	1,100	600
1920	4,000	1,300	—
1925	5,000	2,500	—

It is probable that the British position in relation to coke costs per ton of iron was more favourable at the beginning of the period than at the end. Not only did Britain make more coke than any country up to nearly the end of last century, but the best coal seams were used and production in beehives had been brought to a high degree of perfection, whilst the chamber ovens on the Continent had by no means been perfected. Moreover, the divergence in the average size of blast furnace stack in the various countries was not very large until the end of last century. It was not until after 1890 that the U.S.A. started to build much larger furnaces than in Britain; after 1900 for Germany, and after 1910 for Belgium.

7. CONCLUSIONS

We may conclude that there was nothing seriously wrong with the fuel situation in Britain, and even if the advantages were mainly geographical, Britain was better off in regard to coke costs than some competitor countries. The relative position, however, grew somewhat worse from the beginning to the end of the period. A number of directions in which improvements could have been made have been noted, including grading and blending of coal; closer attention to coking sites; more modern and larger coke batteries

with higher throughput and situated alongside blast furnaces; improved mechanical handling equipment with lower labour costs per unit; more dry quenching of coke; reduction of railway freight rates and a better and fuller utilization of the coke oven gas and other by-products.

The effect of blast furnace practice on the fuel consumption will be referred to in Chapter IV, on pig iron, but it may be mentioned here that high furnace output and low fuel consumption generally go together. On the Continent the furnaces were of a larger size and the hearth radiation per unit of output less. Whether the smaller British furnaces, better adapted to the production of a variety of specialized irons and necessitating less capital outlay, could meet the competition of the larger furnaces, will be discussed below, but at least, in the particular of coke cost at present under discussion, they were at a disadvantage. It has been noted above, however, that a high coke consumption might not in itself be a deterrent provided advantages evolve at a later stage. It does not appear that such advantages were achieved in this country compared with the Continent.

The dependence of the iron industry on cheap coke has been brought out above; in fact, on the average, two-thirds of the coke production in this country is taken by iron and steel works. Sight should not be lost, however, of the fact that there was an alternative demand for coke and there was a tendency for coke makers to become less dependent on the iron makers both in this country and abroad. This was no doubt one of the reasons why British iron makers controlled one-half of the total producton. There was no more certainty of profit in iron making, but fuel supplies are too important a cost constituent to be left in the control of those not interested in the success of the iron and steel industry.

(*d*) General Conclusions on Raw Materials

There is no prima facie evidence of a natural disadvantage.

Although there was a lag in developing native phosphoric ores, Britain was not at any disadvantage in regard to their cost and was favourably situated for importing high grade ores. Similarly in regard to metallurgical coke—whilst the economics of coke production were not fully exploited there is no reason to suggest that Britain was at any disadvantage in quality or price.

We are led to the conclusion, therefore, that Britain was not disadvantageously situated with regard to the economic availability

of raw material supplies at iron-making sites, although in certain directions higher efficiency in their utilization could have been developed.

These deductions corroborate the position outlined in Chapter I, viz., that up to 1914 Britain was successful in the supply of pig iron at home and abroad. One factor in this was the relatively low cost, at the points of assembly, of the raw materials for pig iron production.

After 1918 exports of pig iron fell considerably, but this was not due to changes in the economic availability of raw materials; it was connected with the economic difficulties of the times, the greater use of scrap in steel making and the fact that more basic pig iron was being used than before, which was imported at exceedingly low prices from France, Luxembourg and other parts of the Continent.

On the whole, therefore, there was no factor in raw material supplies that would account for the relative retrogression of the industry or the absolute retrogression of some products. The analysis must, therefore, be extended into other aspects of the industry, such as production, organization and capitalization, in our endeavour to elucidate effective changes other than the general financial and industrial developments discussed in Chapter II.

CHAPTER IV

Was Pig Iron a Weak Factor in the Industry?

(a) Introduction

The pig iron production of the countries under comparison has been given in Fig. I.

Before 1914 production increased even in France and Belgium at a faster rate than in Britain. The trend line in the latter was a convex parabola and after 1907–8 production tended to decrease absolutely as well as relatively. This indicated that neither home consumption nor export was in a position appreciably to increase production. The fall in exports was in part due to other countries tending to put themselves in a position to supply their own requirements of the special irons, which constituted the greater part of British production; for example, by 1912 Germany had made herself practically independent of British foundry iron. Other factors in the situation, besides decreased exports were the decline in wrought iron and the increased consumption of scrap in steel making.

While an increasing proportion of the pig iron made in Britain was used in the molten state, a large quantity was cooled and sold for smelting. The percentage used in producers' works was 44 in 1928, 49 in 1929 and 44 in 1930; thus, even at the end of the period, over 50 per cent was dispatched, indicating that technical integration had not proceeded very far.

(b) Pig Iron Prices

A comparison is made in Table 36 of the pig iron prices ruling in the various countries, but a few cautionary remarks have to be borne in mind. It cannot be assumed that the items compared are exactly identical and prices must not, in the absence of further evidence, be taken as an index of costs of production. Producers in all countries were also accustomed to sell for export at a lower price than to domestic consumers. In the following analysis reference is made only to domestic prices.

The general trend of pig iron prices over the period under review was as follows: the trend from 1873 was downwards, a minimum being reached about 1886 in Britain, Germany and Belgium, in France about 1894 and in the U.S.A. about 1896. During this period a fall in general prices was experienced, but in the making of pig iron technical improvements and improved transport facilities assisted in lowering costs. From the above minimum prices trended upwards till 1913, due to changes in the value of money, though offset to some degree by increased technical efficiency in large quantity production. The prices of raw material rose rather more than proportionately, suggesting that decreasing returns may have commenced to set in. After 1920 pig iron prices fell rapidly until they appeared to rejoin the pre-war trend. The fall in this country was connected with the return to the gold standard and the increase in the value of money, though technical efficiency also increased in proportion as reconstruction and rationalization progressed.

At the beginning of the period pig iron prices were lower in Britain than in Belgium, Germany and France. Prices in the U.S.A. were the highest.

TABLE 36

PIG IRON PRICES—1870–1930

Year	Great Britain	Germany		France	Belgium	U.S.A.	
	Cleveland III	Fdry. III	Lux. III	Fontephosphoreuse	Average	Foundry I	Average
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1870	52 3	—	—	107 0	—	113 0	—
1875	54 6	—	—	91 0	62 0	94 0	—
1880	50 3	—	60 0	63 0	—	116 0	—
1885	33 0	—	30 0	49 0	41 0	75 0	68 0
1890	37 0	72 0	65 0	52 0	—	77 0	67 0
1895	36 0	55 0	44 0	48 0	—	57 0	46 0
1900	70 6	97 6	82 0	95 0	—	86 0	77 0
1905	49 6	65 0	54 0	59 0	47 0	72 6	58 0
1910	50 0	64 0	58 0	67 6	—	71 6	63 0
1913	59 0	74 6	66 0	66 0	—	75 0	62 0
1920	210 0	—	—	190 0	—	—	178 0
1925	73 0	89 0	—	70 0	72 0	—	83 0
1930	67 0	81 0	—	—	—	—	78 0

In the eighties the order of prices was, U.S.A., France, Belgium, Germany, Britain, though in 1885 the price of Luxembourg No. III

E*

Iron was the lowest recorded. From 1890 to 1913, however, the price of British Foundry Iron No. III was the lowest in the world.

Comparing Cleveland No. III with the nearest Continental grades, prices before 1914 were from 2s. to 10s. lower in this country. West Coast hematite was also somewhat lower than German hematite. One of the reasons for British pig iron prices comparing favourably with German was the lower overheads of our pure works relative to the German mixed works. While prices in Europe had showed a steady upward tendency from the nineties, there was a downward trend in the U.S.A. after the turn of the century, and before 1914 American prices had approached those in this country and were, in fact, lower than for some Continental grades. This suggests that technical efficiency was increasing at a faster rate in America than in Europe.

The rapid fall in prices after 1920 necessitates some latitude in estimating average yearly figures, but during the decade 1920–30 prices of French and Belgian pig iron were less than British, whilst American and German irons were dearer. French and Belgian pig iron prices were the lowest in the world, with the possible exception of Indian pig iron, and their export prices were considerably lower than domestic (about 8s. 2d. in 1930).

(*c*) Pig Iron Exports

Though our price advantage continually decreased from 1870 to the outbreak of the European War, Britain maintained a large export trade in pig iron, having a mean of between 1 and 1¼ million tons per annum, with a noticeable upward trend after 1892. The narrowing margin between British and German prices (influenced, no doubt, by the German rebate system and special export arrangements) accounted for the increase in German pig iron exports after the turn of the century up to 1 million tons in 1913.

After 1920 the situation changed and French and Belgian prices governed the world market. French exports of pig iron became the largest in the world and German exports equalled the reduced British figure of approximately half a million tons annually. This was due to the better export organization of the Continental industries, together with their system of rebates, differential export prices and favourable freight rates. Other factors must have been involved, however, as whilst British production fell and exports decreased, world production expanded steadily and imports into this country increased.

In 1890 British imports amounted to about 50,000 tons, but they increased to 200,000 tons by 1900, and were 220,000 tons in 1913. Between 1920 and 1930 the annual imports varied considerably, but in three years (1921, 1926 and 1927) they amounted to half a million tons or over, and consisted mainly of basic pig iron from Belgium, Germany and France.

(*d*) Assembly Costs

The importance of transport costs is due to the fact that materials account for the greater part of the cost of pig iron.

The cost of one ton of pig iron in Germany in 1896 was given as follows:

		per cent	
Materials	Ores	61	82·5
	Fuel	21·5	
Wages		6·1	
Other items		11·5	

This may be compared with the figures given by the British Committee on Industry and Trade in 1924:

	Basic Iron (per cent)	*Hematite Iron (per cent)*
Materials	82·5	82·9
Wages	8·9	10·6
Power	2·9	—
Repairs	3·8	—
Rates, Taxes and Social	0·6	0·7
Other Charges	1·3	5·8

Material at site may therefore be taken as 80 per cent or more of the cost of pig iron of which transport costs may form one-half.

It has already been noted that Britain was as favourably placed as her competitors for costs of assembly in view of the juxtaposition of raw materials, the relative shortness of hauls and the use of coastwise freight. In many cases, however, haulage of raw materials was by rail and in respect of railway freight rates Britain was at a disadvantage.

Railway rates in 1882–83 (pence per ton-mile) were as follows:

	Ore	*Pig Iron*	*Coal and Coke*
Cleveland	0·74 to 1·00	1·0 to 1·8	—
S. Wales	0·92	0·93	—
France	0·66	0·78	0·85
Belgium	0·56	0·88	0·73
Germany	0·51	0·66	1·46
U.S.A.	0·56	0·70	0·55

In 1883 the average costs of conveying minerals per ton of pig iron for the various districts in England were:

	s	d.		s	d.		s.	d.
S. Wales	16	0	Lincolnshire	9	6	Scotland	7	2
Lancashire	15	1	Northants	8	6	S. and W. Yorkshire	7	0
Cumberland	14	8	Cleveland	8	6	S. Staffs.	5	0

In 1884 Bell stated that the cost of transport of the materials consumed per ton of pig iron was 10s. 9d. in Great Britain as compared with 25s. 8d. in the U.S.A. He drew attention, however, to the difference in loading charges in this country, quoting 6d. per ton at Middlesbrough against 3s. for Scotland and South Wales.

In 1900 assembly costs per ton of iron were said to be from 4s. to 7s. and freight rates in Britain twice as much as for journeys of similar length abroad.

Jeans, in 1904, illustrated the importance of transportation of iron-making materials by quoting a blast furnace consuming 3,500 tons of ore, 1,500 tons of coke, and 500 tons of limestone per week to produce 1,500 tons of iron and 1,500 to 2,000 tons of slag.

More slag was produced than iron yet the total material had to bear the high freights which at that time for an average haul of 20 to 30 miles were:

Average rates in 1904

Great Britain	1¼d. to 1½d. per ton-mile
U.S.A.	less than ½d. „ „
Germany	½d. to ¾d. „ „
Belgium	0·4d. „ „

The freight from Stafford to coast was 8s., Pittsburgh to New York, 6s. 6d. to 8s.; Westphalia to Antwerp, 7s. 6d.

Assembly costs were greatest in South Wales and Lancashire, and least in Middlesborough and Scotland.

As regards water-borne transport, however, the freight from Spain to English ports (800–1,000 miles) was 4s. to 5s., compared with 6s. per ton from Lake Superior to Pittsburgh (1,000 miles). Jeans emphasized that France, Germany and Belgium had low internal water transport rates.

In America freight charges on ore remained high in spite of specialization in transport methods. The freight on fuel was also appreciable, although coke was being made nearer to the point of consumption than before. In Germany the coke freight was low,

though the transport charges on ore were high—higher on Lorraine ore (rail-borne) than Swedish ore (sea-borne).

Commissions appointed in Great Britain before and during the European War, 1914–18, also referred to the fact that British railway tariffs were higher than abroad. The following changes in rail freights subsequent to the war, may be noted:

Belgium	Lower
France	About the same
Germany	Higher—60 per cent on pig iron
U S.A.	Higher—60 to 75 per cent
United Kingdom	Higher—60 per cent

(This comparison was made in 1927)

In 1920–30, therefore, Britain was at an increased disadvantage in respect of freight rates compared with Continental competitors.

Owing to the transference of Lorraine the hauls on ore in France were shortened but the freight charges on coke remained high; for Belgium the assembly costs were high on ore and rather high on coke.

The general conclusion is that the relative advantage accruing to Britain was not fully exploited due to high rail freights, and the relatively lower degree of integration tended further to handicap this country, as 50 per cent or more of the pig iron was dispatched in the cold or solid state.

The freight disadvantage persisted over the whole period under review, but was heaviest in the last decade, when the British industry was in greatest need of help to compete with continental industries.

The high freight rates cannot, however, be considered an inefficiency of the industry except in so far as lack of organization prevented negotiation with the railways for lower charges.

(*e*) Changes in British Iron-Producing Centres

Table 37 gives the production of pig iron in the various iron-making centres over the period 1870–1930.

By 1870 the North-East coast had established a leading position as an iron-producing centre which, indeed, it still possesses. Staffordshire, Scotland, South Wales and the West Coast were well established, but Northants and Lincolnshire produced only small quantities of pig iron.

In the eighties, the West Coast took second place as an iron-producing centre, but was surpassed by Scotland in the years preceding the war. From 1920 to 1930 South Wales and Lincolnshire

were competing for second place, and production in the Midlands increased, so that there was a definite change in the centre of gravity of the industry.

TABLE 37

GREAT BRITAIN—PRODUCTION BY DISTRICTS (000 TONS)

Year	*N.E. Coast*	*West Coast*	*Scotland*	*S. Wales*	*Lincoln and Leicester*	*Northants*	*Staffs and Worcester*
1872	1,900	450*	1,080	1,000	50	50	1,190
1882	2,700	1,020*	1,140	940	230	180	800
1899	3,160	1,500	1,160	920	400	290	750
1906	3,500	1,440	1,440	900	490	300	820
1913	3,820	1,060	1,360	890	520	380	800
1920	2,640	1,009	920	580	650	280	720
1925	2,220	640	420	780	540	—	—
1930	1,860	686	466	542	—	—	—

* Cumberland.

Whilst the North-East coast remained the chief source of pig iron in this country, the mining costs of local Cleveland ores were increasing and Northants ore was used as a mixture, but the transport cost was high. First-rate coke was available at low cost and the geographical position was good, but that production costs had increased was shown by the fact that Midland foundry iron was delivered cheaper than local iron and some pig iron was imported from Belgium and India.

Lincolnshire is noteworthy as being the only district showing a continuous increase in pig iron production over the whole period. Its ores, being near the surface, were cheaply mined and made a self fluxing burden, suitable for the basic process, though containing less phosphorus than Northants ores. Fuel was readily obtained from Yorkshire.

South Wales had good local coal, cheap limestone and good port facilities. About 80 per cent of the iron was hematite made from imported ores, in large furnaces built on the coast. This district had no local ores but could obtain them from Northants and Oxford, except that railway rates were high (15s. per ton of iron ore).

Northants had large deposits of cheaply mined phosphoric ores which, mixed with the limey ores of Oxfordshire, would make a suitable basic pig iron at as low a cost as anywhere in the world. Unfortunately coke had to be brought rather a long way, e.g. from South Yorkshire.

Scotland, where the blackband and clay ironstones were declining, and where the furnaces were old and small, and Staffordshire, where the furnaces were old-fashioned, are instances of districts which had lost their economic advantages with the lapse of time.

The economic strength of iron-producing centres, therefore, depended largely on the question of the cost of assembly of raw materials. Sites losing this economic advantage tended to decline. Centres developed where the cost of raw materials assembled on site was more favourable, though the question of distributing finished products and by-products was of considerable importance; South Wales, for example, had its sheet and bar market, and Northants was near the Birmingham market. The above remarks serve to emphasize the burden of railway freight charges on the industry, and in particular suggest that there are only two localities away from the coast where the iron industry can develop—the South Midlands (Northants) and Lincolnshire.

(*f*) Blast Furnace Practice

1. *Types of Iron Produced.*

As changes in assembly costs do not appear sufficient to account for the relative decline under investigation, the question of blast practice and the technical side of iron making will now be examined.

In the above consideration of pig iron prices, the difficulty was indicated of ensuring that the grades of iron compared were the same in the different countries. The production of basic pig iron did not start till 1880, so that at the beginning of the period the iron made was either forge and foundry iron or hematite iron. Comparatively little hematite iron was made on the Continent, while in this country it rose from about one-quarter of the total in the seventies to 40 per cent in the eighties. In the U.S.A. the proportion of hematite was as high, or even higher, than in Britain. The fact that in the seventies Britain produced about as much pig iron as the other four countries put together, had an important bearing on the favourable price margin observed above, and greater experience and advanced technique at the time in forge and foundry iron, combined with a quasi-monopoly in hematite iron, accounted for the extent of British exports to the Continent.

After 1880 the position changed, and the following table gives a comparison, for the five countries under review, of the proportion of the total output constituted by the three types of pig iron: hematite, forge and foundry and basic iron.

TABLE 38

PIG IRON PRODUCTION; PERCENTAGE OF

(a) HEMATITE IRON

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1882	40	15	—	20	50
1894	40	—	—	20	53
1900	40	8	—	—	58
1910	42	—	2·5	—	41
1920	37	7·5	—	2·5	32·5
1925	35	8	—	1·5	25·5
1930	30	8	—	—	23·5

(b) FORGE AND FOUNDRY IRON

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1882	58	66	—	—	—
1890	50	52	—	—	—
1900	46	35	50	30	30
1910	39	24	27	14	21
1920	26	14	—	4	17
1925	31	11	19	4	15
1930	26	9	18	4	11

(c) BASIC IRON

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1882	—	1	—	—	—
1892	4	40	—	7	—
1902	10	61	47	50	12
1912	20	64	65	90	38
1920	33	50	70	90	50
1925	33	59	75	92	53
1930	29	62	80	92	59

The proportion of basic iron increased rapidly in Germany and France in the eighties and in Belgium in the nineties, so that by the turn of the century it amounted to 50 per cent or more, whilst in Britain and the U.S.A. it constituted only 10 per cent or less. By 1913 basic iron amounted to about 95 per cent of Belgium's total, 65 per cent of the production of Germany and France and 40 per cent of that of the U.S.A. Compared with this, the proportion in Britain was 20 per cent, the balance being 40 per cent hematite and 40 per cent forge and foundry. Germany and the U.S.A. were each making as much basic iron as the whole of the British production. Whilst we continued to make large quantities of special grade

irons which were exported mainly to France and Germany, Germany had arrived at the stage of bulk production of pig iron, which accounted for the diminishing price margin enjoyed by British iron.

After 1918, 80 per cent or more of European production was basic iron against our 30 per cent, and Britain continued to make the highest percentages of hematite and forge and foundry iron in the world. The depression in our trade was largely effected by the collapse of markets, but the increasing exports of basic iron from the Continent indicated that prices were much more significant in international trade than quality advantages. British predilection for acid steel may have been technically justifiable, but it also requires to be proved that we could not have produced basic iron as cheaply as on the Continent. Britain had, however, to compete with the highly organized and modernized Continental industries, of which the French and the German produced more pig iron than our total and the Belgian industry nearly as much.

It cannot definitely be concluded that British persistence in traditional iron making was the reason for our waning price advantage. Some of it was enforced by the diverse requirements of the markets, which could only be met by small and versatile units of plant. Nevertheless, there was considerable hesitation in accommodating manufacturing methods to the new trend and in facing up to the financial requirements involved. It is significant to note, moreover, that in view of the neglect of the basic process, the increasing British imports consisted of basic iron.

(2) *Furnace Output*.

Table 39 shows the average output per blast furnace per year in each of the five countries under comparison:

TABLE 39

OUTPUT PER BLAST FURNACE PER YEAR 1870–1930

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1870	8,700	5,000	—	13,500	—
1880	13,000	11,000	8,000	19,500	—
1890	19,000	20,700	16,000	22,500	31,000
1900	22,500	31,000	21,000	27,000	56,000
1910	30,000	49,000	34,500	46,000	100,000
1920	28,000	5,500	37,000	4,000	147,000
1929	48,000	140,000	67,000	70,000	220,000
1930	49,400	128,000	69,000	61,000	165,000

Early attention to stack size outside this country is illustrated by the following data:

TABLE 40

STACK SIZE 1870–1930 (TONS)

Year	*U.K. Average*	*Germany Ilsede Hutte Works*	*U.S.A. Edgar Thomson Works*
1870	30	55	—
1875	34	—	70
1880	46·4	110	134
1885	57·6	144	200
1890	64·6	192	428
1895	75·8	226	—
1900	78	244	700

In 1904 Jeans gave the following comparison, in commenting on the effect of furnace size:

	Great Britain	*U.S.A.*
Average output*	25,000 tons	60,000 tons
Blast pressure	4 to 6 lb.	10 to 20 lb.
Volume of blast	small	large
Ore per ton	2½ tons	1¾ tons
Iron (per cent)	38	50
Life of furnace	long	short
Labour cost per ton	3s. 6d. to 4s.	2s. to 2s. 6d.

In 1911 in Germany the minimum output per furnace was 45,700 tons in Lorraine and Luxembourg: the average in the Saar was 50,000 tons, and in the Rhineland 67,000 tons. The smaller output per furnace in Britain (30,000 tons) was attributed to small units, inadequate appliances (too old and too weak for the function they had to perform) and the high expenditure on labour.

In 1915 the different iron-making districts in Britain were rated in the following order for average furnace output:

	Tons per annum		*Tons per annum*
South Wales	65,000	Durham	39,400
Cleveland	45,800	Lincs	33,300
Cumberland	40,900	Scotland	15,500

About the same time the minimum annual production per furnace in the U.S.A. was 80,000 tons in Alabama and the maximum 135,000 tons in Illinois.

* Average output is greater than average capacity in times of depression as the larger and more efficient furnaces are kept running. Conversely, in times of prosperity and large total production the smallest furnaces are included in the average output figures.

In 1924 the production per furnace placed the British districts in the following order:

1	South Wales	using 80 per cent of imported hematite
2.	North-West Coast	using local and imported ores
3.	North-East Coast	using local and imported ores
4.	Lincs	using self-fluxing local and imported ores
5.	Staffs	using Midland ores
6.	Lancs and Yorks	using Lancashire and Northants ores
7.	Midlands	using local ores
8.	Scotland	using 65 to 70 per cent of imported hematite ore

In 1927 the average stack size was:

	Tons		*Tons*
U.S.A.	506·2	France	172·9
Germany	307·2	United Kingdom	118·2
Belgium	184·7		

(The British figure compares with the stack size in the U.S.A. thirty years previously.)

From the beginning of the period, the average output per British furnace was lower than in some countries, and after 1900 lower than in all the countries under comparison. The general reason for the smaller scale plants in Britain was the high diversity factor in qualities of iron which the industry produced. While furnaces making basic iron can be driven at a rapid rate, fast driving of furnaces making hematite iron reduces the silicon too low and destroys the furnace lining, and a furnace making forge and foundry iron has only about half the output it would have if changed over to make basic or hematite iron. If, however, this is allowed for in the above comparison, the order of the countries would not be altered. France, for example, the country next lowest to Britain, made about the same proportion of forge and foundry iron, and the U.S.A., at the top of the table, made 25 per cent hematite iron against 30 per cent in the case of Britain. The greater variety of iron made in Britain undoubtedly militated against high individual furnace output, but there were also many cases where furnaces ought to have made 750 tons a day whereas, in fact, they did not produce one-half of this quantity, and even foundry iron could have been manufactured in furnaces of 300 to 400 tons daily capacity.

Large blast furnaces may not, however, be of themselves a sufficient explanation of low costs or of a suitable product. It is generally recognized that there is a limit to blast furnace size to give the most economical working, and it would not necessarily have been ex-

pedient for Britain to adopt the large furnaces of the United States and Germany. In 1905 Stead quoted a case where the cost per ton in two U.S.A. furnaces was the same as in English furnaces, and similar individual comparisons have been drawn by other metallurgists, but they were not claimed to be representative practice. The smaller fixed capital charges on furnace construction and auxiliary equipment were also a factor in enabling the British industry to maintain its operations in times of depression.

The problem of blast furnace practice is obviously not a simple one but the general trend cannot be ignored. Towards the end of the period pig iron was produced more cheaply in the larger, wider hearthed, faster driven, mechanically equipped furnaces on the Continent, than in British furnaces. There was, in fact, a considerable upswing in the average size of blast furnaces in this country during 1920–30, showing that the implications above had been recognized. Moreover, the largest furnaces were found in the most important iron-producing centres, such as South Wales and the N.E. coast, showing that traditional practices lingered mainly in the regions which were declining.

Efficiency is, in some ways, a function of size; modern blast furnaces are built for a definite prescription of ore and a definite type of pig iron, and none should have a capacity of less than 100,000 tons per annum. A steel works of 300,000 tons capacity can readily be supplied by two blast furnaces.

In Britain, however, a large proportion of the blast furnaces at the end of the period were antiquated and there were very few properly integrated units. It appears justifiable to conclude, therefore, that Britain failed to keep fully abreast of the economic advantages to be derived from large furnace output.

(3) Mechanical Handling Equipment

In the Appendix (p. 314) a large number of factors contributing towards improved furnace output are tabulated. A number of these are concerned with fuel which has been considered in Chapter III; other factors relate to mechanical equipment and mechanical handling of materials in blast furnace practice.

To this subject greater attention was given abroad, not only in the U.S.A., with which a contrast is usually drawn, but in Germany and Belgium. In the U.S.A. an intensive study of mechanical handling and charging had, of course, been necessitated by high wages, and mechanization had in some cases reduced the number

of operatives required per blast furnace to one-seventh. As wages were higher in Britain than in Germany and Belgium, the economic necessity for mechanization was greater here than on the Continent. Actually it was relatively neglected and even after the European War mechanical charging was almost the exception in Britain. A counterpoise to the lower degree of mechanization was to be found in the lower British charges per ton made, viz. capital, depreciation and maintenance charges, but this was no excuse for not exploiting as far as possible the advantages of mechanization.

By 1930, however, more than 25 per cent of the blast furnaces in Britain were equipped with mechanical charging devices and these were, in fact, the furnaces more regularly in blast. Mechanical casting of pig iron became a more common practice and the percentage of steel made from molten iron was larger than before the European War. On the whole, however, improved handling, charging and auxiliary equipment remained necessary in Britain as well as larger furnaces built and operated on improved lines.

(g) Gross Productivity per Man Employed

An international comparison of productivity is extremely difficult, if not impossible, but data are available to show the average output per year per man employed in the industry.

They are given in the following table and in greater detail in the Appendix (p. 315).

TABLE 41

Production per Man per Year (tons)

Year	*Great Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*Luxembourg*
1880	—	130	110	210	80	—
1889	—	.190	170	270	—	—
1899	—	—	—	—	330	—
1906	340	—	—	390	—	—
1907	—	277	—	—	474	—
1911	440	320	—	—	—	—
1913	—	400	300	470	760	487
1920	200	192	165	259	800	173
1925	268	435	372	430	1,260	381
1926	100	320	340	520	1,150	391
1929	402	600	—	550	1,180	390

The figures relate to the entire industry in the respective countries—not to individual furnaces. Many of the technical reasons for the differences are well known; e.g. size of furnaces, iron content and

reducibility of ore, quality of coke, rate of driving the furnaces, use of mechanical aids, temperature of blast and difference in the type of pig iron produced, but the present object is to supply a statistical comparison.

There are no data available on the number of men employed in Britain on pig-iron making until after 1900, but it is apparent that while in the 19th century Belgium and the U.S.A. showed up best in respect of output per man, Britain did not seriously suffer in comparison up to the outbreak of the European War in 1914.

After the war all countries except the U.S.A. showed the common feature of a fall in production per man followed by a rapid increase, but whereas in the U.S.A. production per man increased 5 per cent between 1913 and 1920, and European countries shortly after attained higher levels than in 1913, Britain hardly attained its pre-war figure and the output of pig iron per man was lower than in any of the countries under comparison. It was, in fact, only one-third of the average for the U.S.A. and two-thirds that of Germany.

This was no doubt connected with the partial working of the British blast furnace capacity as, although the most efficient furnaces would be kept in use, workmen might have been retained ready to light up furnaces if the demand arose. Before 1914 there was some evidence that the average percentage of furnaces in blast was about 60 in all countries except Germany (80 per cent), where the fastest growth in production and exports was to be noted. In the latter part of the decade 1920–30 a 60 per cent average was attained in the U.S.A. and Germany, with France above this average and Belgium sometimes working 100 per cent capacity. In Britain, however, only about 40 per cent of the furnace capacity was operating.

The low output per man, in view of the most efficient furnaces being kept under fire, confirms the evidence above that average British practice and degree of mechanization left much to be desired.

(*h*) Wages Paid in Pig Iron Production

A comparison of wages paid to pig iron workers in the different countries cannot be made with accuracy owing to the varying methods of manning and working the furnaces. It has been noted above, however, that labour costs in pig iron manufacture itself rarely exceed 10 per cent of the total and in the U.S.A. may fall below 5 per cent. Data on this point are given in the following table:

TABLE 42

WAGES IN PIG IRON PRODUCTION EXPRESSED AS A PERCENTAGE OF COST

Country	*Year*	*Type of Iron*	*Percentage*
U.S.A.	1888–89	Bessemer	9·0
U.S.A.	1902–06	Bessemer	5·8
		Basic	5·0
United Kingdom	1903–04	Cleveland	9·0
		Hematite	7·3
U.S.A.	1918	Bessemer	4 9
		Basic	4·7
		Foundry	6·6

This does not include, of course, the labour constituent of the cost of ore and coke and their transport to site. In the production of ore the labour cost may be 40 to 60 per cent of the total and in the manufacture of coke 20 per cent or more, but in the actual conversion of these raw materials into pig iron the direct labour cost is relatively small. It may not, therefore, seem profitable to discuss this item at length as wage variations will not greatly affect the cost of production of pig iron. Broadly speaking, however, money wages in the countries considered have been in the following order from the beginning to the end of the period under review.

1. U.S.A.
2. Great Britain
3. Germany
4. France and Belgium

In 1873–4–5 head blast furnace workers received slightly higher wages in the U.S.A. than here, but on the Continent the wages were considerably lower; in fact, in the early eighties, head keepers in the United Kingdom were paid at nearly twice the wage level ruling in France and Belgium.

TABLE 43

BLAST FURNACE DAILY WAGES: HEAD KEEPERS

Year	*United Kingdom*	*France*	*Germany*	*Belgium*	*U.S.A.*
1873	10/6	3/1–3/8	—	—	7/0 – 9/6 + 25%
1875	9/1	2/9	—	—	6/4 + 25%
1880	8/1	3/6–3/11	3/3–4/0	3/0 – 3/6	—
1881	7/9	3/3–4/4	—	—	—

BLAST FURNACE WORKERS: AVERAGE DAILY PAY IN 1883

	s.	*d.*		*s.*	*d.*
Cleveland	5	3	France	2	9
U.S.A.	6	8	Luxembourg	2	6
Germany	2	10			

In the years preceding 1914 money wages in the iron-making industry were on the average 50 to 60 per cent higher in the U.S.A. than in Britain, and 50 per cent lower in Belgium than in this country.

In 1920–30 the average wage figures in America were about twice the wage level in Britain, though in the case of skilled blast furnace workers the difference in wage rates was not nearly so great. The position of the Continental workers receiving not much more than half the British wages per shift remained unchanged. Data given in the following table show that this relative position persisted in 1930.

TABLE 44

BLAST FURNACE WAGES IN 1926 (PER SHIFT)

Workman	*Great Britain* (*max.*)	*Germany* (*max.*)	*U.S.A.*
Blowers	—	9/9	30/0
Blowing engineers	15/9–18/9	—	22/0
Chargers	18/3–19/3	—	16/7
Keepers	9/0	8/8	19/4
Labourers	—	—	13/0
Slip operators	—	8/9	18/4
Stockers	—	6/7	15/8

BLAST FURNACE WAGES IN 1930 (PER WEEK)

Workman	*Great Britain*	*Germany*	*France*	*Belgium*	*Luxembourg*
Skilled	96/4	68/6	51/6	53/9	49/2
Semi-skilled	72/–	52/10	40/3	38/10	38/10
Labourers	52/5	47/–	32/2	30/10	32/–
All classes average	65/3	50/11	37/–	35/5	36/7

The data above refer to wage rates but furnish no information on the labour costs of production. Wages and earnings have to be related to output per man and it is found that, instead of labour costs being proportional to wages, they usually vary inversely. In 1878 the labour cost per ton was approximately:

North-East Coast	*Lorraine*	*Germany*
4/–	4 marks	3·6 to 4·8 marks

(A mark may be taken as the equivalent of one shilling.)

In 1902 a comparison between Britain and the U.S.A. was as follows:

British Furnace	*American Furnace*
3/6–4/–	2/6

High wages in the U.S.A. were offset by greater economy in man power, the output per man depending less on the personal efficiency of the workmen than on the amount of plant and machinery available. Although wages in the U.S.A. increased steadily from the beginning of the period, particularly in 1920–30, the following figures indicate the fall in labour cost per ton due to the effect of plant improvements and mechanization:

	s. d.		s. d.
1880	11 8	1919	3 1
1890	6 8	1930	1 8
1900	5 0		

The increase in gross productivity was faster than the rise in wages as blast furnace weekly wages increased 96 per cent between 1913 and 1928, whilst the tonnage per man increased 110 per cent. In 1925 the American wage was 100 per cent above the British, but the wage rate per ton was only 60 per cent of the rate in this country.

The countries producing the low-priced pig iron imported into Britain in 1920–30 were the low-wage countries of the Continent, but to conclude that their strong competition was due to the lower wage level is wrong, at least if unqualified. Although evidence may be produced purporting to illustrate the cheapness of low wages (e.g. in 1925 the U.S.A. produced nearly 50 per cent of the world's pig iron, but Indian and British pig iron was imported on the Atlantic coast cheaper than the home product), it ignores all reference to efficiency of production and natural advantages. Wages in France and Belgium were much lower than in Britain at the beginning of the period when we exported large quantities of pig iron at prices appreciably below those ruling on the Continent. The change was due to the fact that whilst money wages remained low on the Continent, efficiency in the production of pig iron, as measured by the output per man employed, not only caught up but surpassed British practice. Complaints were frequently made of the burden of British wages, but it was not so much their absolute level as the labour cost which was high. To have reduced the wages of pig iron workers a small percentage would have made no appreciable difference to the total cost of production, which consisted mainly of the raw materials charged to the furnace. The wage level in Britain could only have been maintained above that on the Continent by higher technical efficiency and by the fuller exploitation of our natural or geographical advantages to reduce assembly costs.

(i) CONCLUSIONS

In summary, it cannot be said that there were serious disadvantages in the cost of pig iron production in this country, at least up to 1913, but the British position subsequently deteriorated and production decreased not only relatively but absolutely. We had a remarkably strong technical start and also geographical advantages, but with the invention of the basic process, assembly costs in some parts of Western Europe were no higher than here. The wrought iron industry declined and there was a decreasing demand for our forge and foundry irons. The ore position also changed, British hematites tended to become exhausted and mining costs in our principal iron-producing centres increased. Internal freight rates remained high. Basic Bessemer steel was discredited here and the production of basic iron was neglected for a time. Original British work in fuel economy was more intensively followed up abroad where larger furnaces were built to obtain larger throughput and lower coke consumption. All aspects of mechanical handling were developed and exploited abroad to a greater extent than in this country, with a view to obtaining lower labour costs. The increased production per man employed in the industry abroad militated against the retention of the higher wage level here than on the Continent. The British industry remained, however, in a strong position up to the European War owing to the demand for the special pig irons made. After the war the Continental plants were rebuilt or reconstructed and compared with these plants, parts, at least, of our industry were obsolescent.

The strongly organized Continental industries, faced with an increased necessity for export, competed strongly in world markets by means of discriminatory prices, and in this country the pig iron makers, working at only a fraction of capacity and with increased overhead charges, were underquoted. Exports diminished and imports increased.

The industry was, of course, aware of the improvements in European methods of production, the necessity for scrapping obsolete plants and for radical modernization and reconstruction. Steps were taken to this end, but the problem was to maintain equipment at a high level of production without inflating capital. A conservative estimate of the cost of bringing the industry up to date was £18,000,000.

Improvements in some regions were more imperative than in others, e.g. Scotland was the least efficient. It was also known that

the whole of the British hematite and basic pig iron could have been made in ten properly integrated units. Nevertheless, some iron-making districts were able to produce at a low cost, e.g. the South Midlands, though neglected, was one of the cheapest sources of pig iron.

It is concluded that, although the deterioration of the industry was influenced by unfavourable post-war factors beyond its control, there is evidence of long-standing neglect of plant development and organization in anticipation of the trend of pig-iron making.

CHAPTER V

Was Wrought Iron a Weak Factor in the Industry?

Wrought or puddled iron is such a relatively small factor in the total economy of a modern iron and steel industry that it may appear superfluous to pursue this question. Before the period under review opened, the wrought iron industry was doomed, except for a few special applications, by the invention of mass production methods of steel making. For twenty years, however, wrought iron made every effort to survive, and world production slightly increased, but after 1890 production in all countries decreased up to the present day. Some particulars of this retrogression are given below, though the economic importance of the industry does not justify detail. It is already apparent, however, that, if wrought iron introduced a weak factor in British iron and steel, we have not to look for a factor retarding development relative to other countries, but to enquire if it was more difficult for the inevitable decline to occur here than abroad, whether from the size or organization of the industry, or a more tenacious adherence to the traditional forms of iron making.

(a) Wrought Iron Production

Some data on the production of puddled iron by the countries under review were given in Chapter I (*a*), and yearly figures are shown in Table III in the Appendix.

From these the ratio of wrought iron to pig iron production in the five countries under comparison has been calculated.

TABLE 45

Ratio of Puddled Iron Percentage to Pig Iron Production

Year	*Britain*	*U.S.A.*	*Germany*	*France*	*Belgium*	*World*
1870	43·7	68·0	72·0	55·0	86·0	59·0
1880	26·0	55·0	46·0	60·0	72·0	42·0
1890	23·5	34·2	36·0	50·0	67·0	32·0
1900	13·0	16·0	12·8	27·0	36·5	17·0
1910	11·1	6·5	2·7	13·4	8·8	7·3
1913	11·8	5·6	1·3	7·3	5·3	5·3
1920	7·4	3·8	1·2	1·3	1·8	3·7
1925	3·6	2·5	0·9	1·4	1·0	1·6
1930	1·8	—	0·21	1·1	—	0·75

It will be noted that from 1870 to 1900 the proportion of pig ron made into wrought iron was lower in Britain than in any ther country, but from 1913 onwards the ratio was higher than n the other countries, showing a tendency of the industry to persist n Britain, when other countries were turning more of their pig iron nto steel.

The production of finished iron was sometimes smaller but generally larger than that of puddled bar. When the output of inished material was larger it was due to the working up of blooms and scrap piles in the rolling mills. In Belgium the finished iron was several times the quantity of puddled iron produced.

The principal products of finished iron were:

Bars and rods
Hoops and strips
Angles, tees and sections
Pipes and tubes
Sheets
Forgings
Wire rods and slit nail rods
Rails

In 1870 world production of wrought iron was about 7 million tons. It rose to a maximum of 8½ million tons in 1890 and then declined to just over 4 millions in 1913 and 1 million in 1927. Britain produced in 1870 over 2½ million tons of wrought iron and reached its maximum output in 1882, when its position as a wrought iron producer relative to other countries was as follows:

	Million Tons		*Million Tons*
Britain	2·84	France	1·07
U.S.A.	2·22	Belgium	0·50
Germany	1·49		

Britain retained its premier position for three more years, although production was falling. From 1891 to 1895 her output was less than 1 million tons, but a slight increase occurred before the outbreak of the War. Between 1920 and 1930 production fell to less than 200,000 tons.

To illustrate the shift of the industry in Britain, districts are given in order of importance in 1882 and 1907.

1882	1907
Cleveland	South Staffs
South Staffs	Scotland
Lancashire	S. and W. Yorkshire
S. and W. Yorkshire	Lancashire
Scotland	North Staffs
North Staffs	Cleveland

The rapidity of the change over from wrought iron to steel is indicated in the following figures:

TABLE 46

RATIO OF WROUGHT-IRON PRODUCTION TO TOTAL FINISHED IRON AND STEEL PRODUCTION IN BRITAIN

Year	*Per cent*	*Year*	*Per cent*	*Year*	*Per cent*
1870	92·5	1900	19·2	1920	9·7
1880	61·0	1910	14·8	1925	5·7
1890	35·0	1913	12·6	1930	3·5

One of the chief wrought iron products was rails, which were used for the Stockton and Darlington Railway, and reached their maximum output in 1871. In Britain the change over from iron rails to steel rails occurred between 1870 and 1880, as shown in the following table:

TABLE 47

GREAT BRITAIN: PRODUCTION OF RAILS 1870–82 (000 TONS)

Year	*Wrought Iron*		*Steel*	
1870	—	1,350*	—	—
1871	1,000	1,370	200	—
1872	975	1,270	250	—
1873	750	1,005	300	—
1874	700	1,005	350	—
1875	300	865	400	—
1876	250	855	470	400*
1877	200	820	565	510
1878	120	775	700	630
1879	70	675	560	520
1880	170	350	810	730
1881	150	150	1,080	1,020
1882	60	60	1,280	1,230

Data published by Sir David Dale.

A further illustration of the decline of wrought iron rails is given in the following figures of production for the north of England:

Year	*Tons*	*Year*	*Tons*
1872	325,000	1905	605
1882	5,600	1913	369

Wrought iron was used for other structural purposes on railways, and for bridges and ship-plates. In 1883 wrought iron plates reached their maximum output in Britain—732,000 tons—but by 1891 they

had been practically replaced by steel plates in spite of the fact that they were lower in price.

In the U.S.A. the trend of wrought iron production was upwards from 1870 to 1890 and since 1886 American output has, in fact, been the greatest in the world. After the maximum in 1890 production fell away slowly until 1913, and although it fell rapidly during the European War period, output during the decade 1920–30 was greater than that of all the other countries put together.

In Germany the struggle between wrought iron and steel was at its height in the eighties, and the output of mild steel already exceeded that of wrought iron in 1888, although the maximum for wrought iron occurred a year later. At no time did the output equal the British figure, and it may be noted that after 1905 German production fell steeply away, whereas the British output increased up to 1913.

In France the maximum output of wrought iron was reached in 1882, though the rise and the subsequent fall in output were very slow.

In Belgium the output was about half a million tons annually from 1870 to 1890, but then fell away slowly at approximately the same rate as the French.

A common feature of the European production was its fairly rapid fall after the turn of the century and small total in the years 1920–30.

(*b*) Prices

The course of British prices for marked and unmarked bars is shown in Table 48, with some figures for foreign bars.

With the exception of peak prices in 1872 (£14), 1873 (£15 15s.) and 1900 (£11 2s. 6d.), British prices remained fairly constant up to 1913 at about £7 10s. for marked bars and £6 for unmarked bars. After an all-time peak price of £31 10s. in 1920 marked bars settled down to £12 2s. 6d. and unmarked bars were also 60 per cent above their pre-war levels. The price of finished iron in the Midlands was, till 1914 a few shillings above that in the north of England. In foreign prices there was a close correlation of cyclical changes up to 1913. German bars stood at roughly the same price as British unmarked bars, and Belgian and French bars were lower. In the U.S.A. prices were comparable with those of unmarked bars up to 1900, but after the turn of the century they were about the same or slightly above those of marked bars in Britain and after the war considerably higher

TABLE 48

WROUGHT IRON—PRICE OF BARS

Year	Great Britain: Marked	Great Britain: Unmarked	Germany: Schweisstabeisen	France	Belgium	U.S.A.: Iron Bars—Pittsburgh
	£ s. d	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1870	8 2 0	6 16 0	—	7 2 6	—	—
1875	10 0 0	8 7 6	—	8 0 0	—	—
1880	8 2 0	6 16 0	—	5 10 0	5 16 0	7 0 0
1885	—	5 0 0	—	4 10 0	4 15 0	5 5 0
1890	8 16 0	7 0 0	8 12 6	5 0 0	—	—
1895	7 0 0	5 15 0	5 2 0	4 10 0	—	—
1900	11 2 6	10 0 0	10 10 0	6 15 0	—	10 0 0
1905	8 2 0	6 2 0	6 16 0	4 15 0	—	8 15 0
1910	8 0 0	6 5 0	6 12 6	5 7 6	—	8 12 6
1913	9 11 0	7 12 6	—	5 9 0	—	8 0 0
1920	31 10 0	29 0 0	—	—	—	22 5 0
1925	14 12 0	12 5 0	—	6 10 0	—	21 0 0
1930	12 2 6	9 10 0?	—	—	5 10 0	19 0 5

It is apparent that British marked bars sold on quality but that as regards unmarked bars the Continental countries could compete in price up to 1913, and after 1920 they had a considerable advantage. We may say, therefore, that there was difficulty even before the European War in holding down British prices to those of Continental countries. After the war, French and Belgian prices returned almost to their previous levels while British prices had increased 60 per cent. This explains why large quantities of bars were imported into this country particularly from Belgium.

The price of iron rails after a peak in the seventies stood at about £5 10s. in the north of England and remained approximately the same up to 1913. From 1900 to 1913 the price of iron hoops was slightly less than that of marked bars (£7 10s.) and in 1920–30 fell to £11 against £12 for marked bars.

(c) FOREIGN TRADE

IMPORTS OF WROUGHT IRON

From 1893 to 1913 British imports averaged 15 per cent of the annual production. From 1925 to 1927 they were considerably over 50 per cent. In 1913 Britain imported 32 per cent of the total

Belgian production of finished iron, in 1923 57 per cent, and in 1924 80 per cent. The resultant displacement of British labour was said to amount to 6,000 men.

British makers complained that the material coming from the Continent was not puddled bar and that it was misrepresentation to describe it as finished iron. It was well known that the inside of the piles of puddled bars were filled with scrap by which process several tons of "finished iron" would be produced from one ton of puddled bar. At the same time Belgian bars continued to be bought in large quantities, so the material must have served its purpose

Exports of Wrought Iron

The percentage of British production exported was: 30 per cent in 1875, 57 per cent in 1887 and 18 per cent in 1913. Exports and imports were mainly of wrought iron bars, so that the same product moved out of and into the country simultaneously. Before the War exports were greater than imports, in 1920–30 this was reversed.

Wages

One of the causes of the strong Continental competition was the higher level of wages in Britain. Efficiency in the puddling process depends mainly on man power, so that while the English puddlers may have been more highly skilled, it is doubtful if their higher output, even at the beginning of the period, was compensated by their higher wage rate. In the early seventies it was, in fact, known that an advantage in labour cost lay with the Continent. Towards the end of the period reviewed the disparity was considerably greater.

(*d*) Technique

Production in puddling furnaces is necessarily limited to small quantities. The output of a puddling furnace is normally 4 heats of 5 cwt. each per shift of eight hours. Moreover, to produce 1 ton of puddled iron bars, nearly 2 tons of fuel is required. In comparison, the fuel consumption in open-hearth steel furnace practice (100 tons or more capacity) is 5 to 7 cwt. per ton of steel output.

In the early seventies there were 8,000 puddling furnaces in Britain, and in 1874 7,575 were working. The number fell off as follows:

1880	7,000	1900	1,500
1890	4,000	1913	1,500

The maximum output per puddling furnace varied in the eighties between 575 and 675 tons per annum. The output per furnace seems to have been somewhat lower in Germany but about the same in France and Belgium as in Britain. The maximum number of iron rolling mills in Britain was just over 1,000 in 1872, and the maximum output per man employed was 200 tons per year.

The gross productivity per man employed in puddling furnace works was, at the beginning of the period, about 30 tons per annum in Britain, France and Germany, but higher in Belgium (40 tons) and the output per man only increased very slowly as the period progressed.

(*e*) Conclusions

The period under review saw the wrought iron industry reach its zenith, but already doomed by the advent of the large-scale steel-making processes. The struggle was not, however, given up without fighting to the bitter end, and money was spent liberally to place the industry on an economic basis. Between 1875 and 1885, £4,660,000 capital was invested in puddling furnaces, but it was nearly all lost. Development of the Danks rotary mechanical puddling furnace was abandoned under the impact of the basic steel process, but dumps of puddling cinder became valuable to increase the phosphorus in pig iron for the basic process of steel making.

Apart from the fact that the industry was doomed even if this was not recognized at the beginning of the period, criticism was raised of inefficient British furnaces, mills and hammers. The rolling mills were said to be somewhat out of date and the heating furnaces uneconomical. The criticisms do not appear to have been true to any great extent relative to other countries. Even by 1870 wrought iron manufacturers were pooling their knowledge. Helvers and squeezers were giving place to double-acting hammers and more economical fire grates, steam rabbles, mechanical rabbles, oscillating beds, revolving furnaces and improved fettling were being introduced and waste heat boilers attached to puddling and mill furnaces. The handicaps, if any, lay, to some extent, in British adherence to traditional methods of manufacturing and marketing. Improvements were certainly possible in the modernization of plant, development of mechanical puddling processes, use of gas furnaces and electrification of auxiliary equipment, but they would not have saved the industry from the inevitable decline. British iron makers were organized, but there was no central selling agency and the decline

persisted in spite of the formation in 1919, of the British Iron Manufacturers' Research Association.

The industry did not, in fact, decline after 1900 faster than those on the Continent and in America. The mistake was to preserve the industry to a greater extent than economically necessary after the advent of cheap mild steel. This was no doubt influenced by the large production and export of British forge pig iron for which there was, of course, a falling demand. There will always be a demand, to a limited extent, for wrought iron on account of its special properties, but it will remain a small item in the total output of the iron and steel industry.

The wrought iron industry has, however, left a special inheritance which it is worth while noting in relation to the next chapter of this study—steel production, for the mistake was made of basing the steel industry on the location and lay-out of the iron industry.

CHAPTER VI

Was there a Weak Factor in Steel Production?

(a) Production

The output of steel in the countries under comparison and the world total have been given in summary in Table 3 and the trend curves, based on five-year averages, are plotted in Fig. I. Annual figures are given in Table 89 of the Appendix.

It will be noticed that Britain was the largest producer in the world up to 1886, when we were surpassed by the U.S.A., and that German production first exceeded the British total in 1893. Up to 1913 the rate of increase of production was more rapid not only in the U.S.A. and Germany but also in France than in this country.

After 1920 British steel production tended to fall slightly, whilst production in the U.S.A., Germany, France and Belgium increased.

(b) Price Trends

In attempting to compare the prices of steel products in various countries considerable difficulty arises from the lack of statistical data. In Britain, in particular, there are no data on prices of ingots and billets until just before the War. At the beginning of the period under review British prices for raw steel (ingots, billets, slabs) must have been lower than abroad, but, as in the case of pig iron, there is evidence that after the turn of the century the cost of foreign raw steel was equal, and in some cases below, that in this country.

Table 49, for example, gives some prices on steel billets in the countries compared. It is obviously necessary to compare prices for the same thing, i.e. steel made by the same process, and whilst this cannot be exactly assured, the prices given are representative.

Billets and steel bars were the largest items in our pre-war imports, indicating that, unless discriminatory export prices is the full explanation, Continental countries had surpassed Britain early in the century in the cheap production of raw steel, a position which was enhanced after the war, particularly as regards French and Belgian products.

TABLE 49

AVERAGE PRICE OF STEEL BILLETS (PER TON)

Year	*Britain* Billets Hard *Iron and C.T. Review* £ s. d.	*Germany* Thomas Billets £ s. d.	*U.S.A.* Bessemer Billets Pittsburgh £ s. d.	*France* Aciers Marchands £ s. d.	*Belgium* £ s. d.
1890	—	5 5 0	—	5 5 0	—
1900	—	6 5 0	5 10 0	6 15 0	—
1910	—	5 0 0	5 10 0	5 5 0	—
1913	6 2 6	4 15 0	5 10 0	5 5 0	—
1925	8 10 0	6 0 0	7 10 0	4 17 6	4 17 6
1930	7 10 0	—	—	—	—

With regard to the cruder forms of finished rolled products, prices of girders, joists and beams were lower in Germany in the eighties than in Britain, and in pre-war years Continental prices were definitely below ours, as shown ni the following table. After the war the price difference was at least doubled, though, on the other hand, British prices compared favourably with those ruling in the U.S.A.

TABLE 50

AVERAGE PRICE OF GIRDERS (PER TON)

Year	*Britain* Joists £ s. d.	*Germany* £ s. d.	*U.S.A.* Beams, Pittsburgh £ s. d.	*France* £ s. d.	*Belgium* £ s. d.
1885	5 15 0	4 15 0	—	—	—
1901	—	5 10 0	7 5 0	—	5 12 6
1907	7 5 0	6 5 0	7 15 0	—	—
1913	7 5 0	5 15 0	7 0 0	5 15 0	6 10 0
1925	8 0 0	6 0 0	9 5 0	—	5 15 0
1929	8 0 0	5 15 0	9 0 0	5 5 0	5 0 0

Up to 1900 British quotations for steel rails were considerably below German and American figures. Belgian prices then became competitive and remained below British figures up to 1914. American prices were stabilized after 1901 at about £6 per ton, and British and German prices oscillated above and below this. In 1920–30 American prices were stabilized at about £8 15s. per ton, with British quotations just below this figure, but Belgian and French prices were as low as £6, with German prices intermediate.

British prices for merchant bars compared satisfactorily with German figures up to 1900, but with the turn of the century Continental prices including German fell below ours and the U.S.A.

quoted equal figures. In 1920–30 French and Belgian prices were still further below British prices, but German prices rose nearer to British. American prices, though relatively high, were falling rapidly.

TABLE 51

AVERAGE PRICE OF STEEL RAILS (PER TON)

Year	Britain £ s. d.	Germany £ s. d.	U.S.A. £ s. d.	France £ s. d.	Belgium £ s. d.
1870	—	9 5 0	—	—	—
1880	6 7 6	6 15 0	—	—	—
1890	6 9 0	7 17 6	—	—	—
1900	8 15 0	9 0 0	7 10 0	—	—
1905	6 10 0	5 10 0	7 0 0	—	5 0 0
1910	7 0 0	5 10 0	6 15 0	—	5 5 0
1913	8 5 0	5 10 0	7 0 0	8 5 0	5 12 6
1922	9 6 0	—	8 10 0	8 0 0	7 0 0
1929	8 10 0	7 0 0	8 0 0	5 5 0	5 12 0

TABLE 52

AVERAGE PRICE OF MERCHANT BARS (PER TON)

Year	Britain £ s. d.	Germany £ s. d.	U.S.A. £ s. d.	France £ s. d.	Belgium £ s. d.
1880	6 8 0	7 8 0	—	—	—
1885	4 17 6	5 2 6	—	—	—
1890	6 10 0	7 19 0	—	—	—
1895	4 15 0	5 10 0	—	—	—
1900	8 12 6	9 0 0	7 10 0	—	—
1905	6 10 0	5 10 0	7 0 0	—	5 0 0
1910	7 0 0	5 10 0	6 17 6	—	5 5 0
1913	8 5 0	5 10 0	7 2 6	8 5 0	—
1923	9 0 0	—	10 5 0	8 0 0	7 10 0
1928	7 10 0	7 0 0	8 12 6	5 10 0	5 10 0

Price comparisons on plates and sheets are somewhat difficult as there are several categories—e.g. plates, thick sheets and thin sheets—and the line of demarcation is not the same in all countries. Table 53 gives, however, some data on these products. For ship-plates, British prices were competitive up to 1913; in other categories, such as boiler plates, Continental producers were underquoting us before that date. In thick sheets, prices in this country appear to have been as low as any, and in thin sheets—e.g. galvanized or tinplates—British prices were always the lowest.

Between 1920 and 1930 Continental quotations for plates and sheets were below British prices, the lowest occurring in France and

TABLE 53

PRICE OF PLATES AND SHEETS

Year	Great Britain			Germany		USA		France		Belgium	
	Ship Plates	Plates	Thick Sheets	Boiler Plates	Thick Sheets	Tank Plates Pittsburgh	Thick Sheets	Plates	Thick Sheets	Plates	Thick Sheets
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d	£ s. d.	£ s. d.
1880	6 10 0	—	—	—	12 0 0	—	—	—	—	—	—
1890	8 10 0	9 5 0	—	12 0 0	10 10 0	—	—	—	—	—	—
1895	4 17 6	5 17 0	—	6 10 0	5 0 0	—	—	—	—	—	—
1900	8 0 0	9 15 0	10 2 6	10 12 6	8 5 0	7 5 0	7 2 6	—	—	—	—
1905	6 0 0	7 2 6	7 5 0	6 15 0	6 0 0	7 10 0	7 7 6	—	—	—	5 2 6
1910	6 10 0	7 2 6	7 10 0	6 10 0	6 0 0	6 15 0	6 17 6	—	—	—	5 10 0
1913	7 15 0	8 15 0	—	6 5 0	5 0 0	7 0 0	6 17 6	—	—	—	—
1922	10 5 0	9 10 0	—	—	—	8 0 0	8 2 6	5 10 0	7 5 0		—
1925	8 15 0	8 10 0	—	7 5 0	7 10 0	9 0 0	9 2 6	10 10 0	11 10 0	8 5 0	7 15 0
1930	8 15 0	—	—	—	9 5 0	8 0 0	—	8 0 0	7 15 0	6 12 6	5 15 0

PRICE OF GALVANIZED SHEETS (£ PER TON)

Year	*Great Britain* £ s. d.	*U.S.A.* £ s. d.	*U.S.A.* $ *per 100 lb.*	*Year*	*Great Britain* £ s. d.	*U.S.A.* £ s. d.	*U.S.A.* $ *per 100 lb.*
1900	14 17 6	—	—	1920	62 0 0	66 0 0	7·00
1905	10 17 6	16 0 0	3·50	1925	16 10 0	21 0 0	4·55
1910	11 12 6	15 12 0	3·40	1927	14 10 0	16 0 0	3·70
1913	10 18 0	14 10 0	3·15	1930	12 15 0	14 5 0	3·10

Belgium. It must be borne in mind, however, that the plates, sections, etc., from these countries were chiefly of basic Bessemer steel, whilst the British steel was made in the open-hearth furnace and cost 7s. 6d. to 10s. 6d. per ton more to produce in the ingot form. After the war Britain was only able to maintain prices below foreign quotations in thin sheets. In all products, from billets to tinplates, American prices were the highest.

The following table of prices for tinplates indicates that since 1900 prices per box in the U.S.A. have closely approached the prices ruling in South Wales.

TABLE 54

PRICE OF TINPLATES (PER BOX)

Year	Great Britain s.	Great Britain d.	U.S.A. s.	U.S.A. d.	Year	Great Britain s.	Great Britain d.	U.S.A. s.	U.S.A. d.
1890	15	9	25	0	1913	13	3	13	6
1895	12	0	19	3	1925	20	3	21	0
1904	14	0	14	3	1930	18	0	20	9

A confirmation that the principal competition in 1920–30 came from France and Belgium is given by the following relative prices compiled by Professor Bowley in 1925, taking 1913–14 as 100.

Product	*Great Britain*	*Belgium*	*France*	*U.S.A*
Pig Iron	106	104	91	135
Wrought Iron	147	115	74	170
Steel	123	114	—	132
Steel Products	116	104	85	141

A comparison in 1927 also showed that (with certain exceptions in the case of Germany) British prices f.o.b. were higher than Continental in billets, structural shapes, rails, merchant bars, ship-plates, black sheets, wire rods, hoops and strips, plain and galvanized wire and wire nails. British prices for galvanized sheets were, however, well below those of France, Belgium and Germany, and tinplates for export were 40 per cent below German figures.

On the Continent there was, as previously indicated, a considerable margin between domestic and export prices, though it should be noted that British export prices were somewhat lower than home prices, due to the operation of a rebate system. There was a higher correlation between price and production cost in England than in Germany, showing that British prices were more dependent on export.

An indication of the margin between Continental home and export prices is given in the following table relating to December 1929 and 1930. It is appreciated that the period taken was just at the decline of a boom when competition was intensified.

TABLE 55

CONTINENTAL STEEL PRICES

Material	*Domestic Prices*			*Export Prices f.o.b. Gold Basis*
	Germany	*France*	*Belgium*	
	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*	£ *s.* *d.*
Foundry Pig Iron				
Dec. 1929	4 5 0	3 16 0	3 11 6	3 8 6
Dec. 1930	4 3 0	2 10 0	2 17 0	2 10 0
Billets				
Dec. 1929	5 19 0	5 0 0	5 1 0	4 10 0
Dec. 1930	5 15 6	3 19 0	3 15 6	3 12 6
Sheet Bars				
Dec. 1929	6 4 0	5 5 0	—	4 13 0
Dec. 1930	6 0 6	4 4 0	4 0 0	3 14 6
Merchant Bars				
Dec. 1929	6 18 0	5 13 0	6 3 0	5 5 0
Dec. 1930	6 14 0	4 7 0	4 8 6	4 4 6
Joists				
Dec. 1929	6 15 0	5 13 0	5 7 6	4 19 0
Dec. 1930	6 11 0	5 0 0	4 6 0	3 15 6
Heavy Plates				
Dec. 1929	8 0 0	6 7 6	6 1 0	6 5 0
Dec. 1930	7 15 0	6 2 6	5 0 0	4 17 0

The above review of steel prices indicates that some of the difficulties experienced in Britain were found in the steel making and heavy trades of the industry before 1914 and to an increased extent after the War. Prices for all steel products except thin and special sheets were led or governed by Continental prices. In the following sections enquiry will be directed to the possible causes; e.g. development of the industries on different lines, differences in steel plants and steel-making practice, differences in plants for working steel, differences in wages and gross productivity of workmen and discriminatory prices and freight rates for export.

(c) Foreign Trade

1. Exports

From 1870 to 1900 Britain occupied an unchallenged leadership in exports of iron and steel; in fact, it was not until 1900 that any other country attained one-third of the British total (see Table 5 Chapter I (a) giving the yearly tonnage for the countries under comparison).

In the seventies the principal constituent of British exports was pig iron, followed by rails. Steel exports were small and less than one-tenth of that produced. Over one-half of British exports went to iron-producing centres, principally to the Continent, followed by the U.S.A., with the British Empire third.

A growth of exports from Germany and Belgium was, however, to be noted, and in the eighties German exports began to enter British colonies. In the nineties the growth of exports from the U.S.A. was the principal feature, the amount of iron and steel sent to Europe rising at a time when British exports to the Continent tended to fall. Competition from the Continental countries was also increasing.

By 1900 Germany was applying considerable energy in an effort to keep its large-scale plants working continuously by export bounties and other means, and British finished products, such as sheets, tubes and wire, were already tending to become dependent on imported semi-products. While British exports continued to rise this was due to expansion in Empire countries. From 1900 to 1913 German exports increased rapidly and surpassed in tonnage the British total from 1910 onwards, after 1908 the imports of the U.S.A. and Belgium also increased rapidly. Competition in world markets had now become serious. In 1913 Britain exported half the tonnage of her total output: the principal item in British exports was still pig iron (25 per cent of the total), but our exports of highly finished products—thin sheets—continued to increase. Exports of rolled products amounted to nearly 75 per cent of home consumption but were losing ground in the export of common grades and semi-finished products. Germany was increasing her export of heavy rolled products and merchant steel, and Belgium that of bars, shapes and angles. In 1920–30 Britain was surpassed by her Continental neighbours in exports of iron and steel: the most significant increase occurred in the case of France, but Belgium also made considerable gains, her exports increasing faster than

ıose of Germany. The increase in British exports during this eriod was due mainly to colonial preference. Continental exporters ad, in fact, regained their pre-war position by 1922 and in 1925 assed their previous total. From 1924 they were determining world rices.

Whilst world exports increased, Britain's share became a connuously decreasing percentage. An identity was apparent between ıe pre-war and post-war trends. British exports were mainly erolled products and thin sheets, but our exports of plates and ıeets did not keep pace with those of our competitors. Even in tinlates and galvanized sheets our exports were meeting with a ertain amount of challenge, as shown in the following table, but it ıay be noted that in 1929 Britain still exported 40 per cent of the ɔnnage of her total output.

TABLE 56

EXPORTS OF TINPLATES AND GALVANIZED SHEETS

Tinplates (000 tons)				Galvanized Sheets			
	Britain		*U.S.A.*				*Germany*
Year	*Total*	*To U.S.A.*	*Total*	*Year*	*Britain*	*U.S.A.*	*(tin, galvanized and coated)*
870	100	75	—	1895	204	—	—
880	245	185	—	1900	250	—	—
890	424	330	—	1905	408	—	—
900	273	55	—	1910	595	—	—
910	483	—	12	1912	658	186	—
913	495	—	73	1913	762	114	27
920	343	—	226	1920	410	108	12
925	493	—	161	1925	704	—	—
930	509	—	224	1929	711	151	81
				1930	431	93	86

'alue.

The total value of British iron and steel exports are given in 'able 57. It was surpassed by that of Germany before the ıuropean War in 1914, and also in 1920–30 approached by all the ther countries considered in this study.

verage Value.

The average value per ton of iron and steel exports from Britain given in the following table, with some figures for other countries ɪr comparison. The average value of exports trended upwards from

TABLE 57

IRON AND STEEL EXPORTS: TOTAL VALUE (£mn.)

Year	*Great Britain*	*Germany*	*U.S.A.*
1870	23·5	—	—
1880	27·0	12·0	—
1890	31·2	—	—
1900	33·5	—	—
1905	31·9	25 3	11·9
1910	43·0	34·5	16·5
1913	54·4	55·2	30·0
1920	129·4	—	—
1925	68·2	48·6	45·8
1929	68·0	94·5	59·7
1930	51·3	—	—

1887, but it is noteworthy that an increase in exports of finished steel was common to all countries considered, particularly the U.S.A. and Germany, for which countries the average value per ton rose to and even exceeded the British figure. French and Belgian average prices were, however, definitely lower than British prices. If corrected for the change in value of sterling, the average value of British exports increased very little compared with the pre-war years.

TABLE 58

IRON AND STEEL EXPORTS: VALUE PER TON

	Great Britain			*Germany*			*U.S.A.*			*France*		
Year	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*	£	*s.*	*d.*
1870	8	12	6	—			—			—		
1880	7	12	6	—			—			—		
1890	8	0	0	—			—			—		
1900	9	3	0	—			—			8	0	0
1910	9	5	0	8	15	0	—			9	2	6
1913	11	1	0	10	10	0	11	0	0	9	10	0
1920	40	0	0	—			—			—		
1925	18	5	0	18	10	0	25	15	0	15	15	0
1930	16	4	0	19	5	0	—			—		

CHIEF EXPORT CONSTITUENTS:

The principal components of the exports of Britain, Germany, France, Belgium and the U.S.A. are detailed in Appendix VI, Table 112. So far as Britain was concerned pig-iron was the chief constituent up to 1906, with rails the next largest single item, followed by galvanized sheets and tinplates. The order of importance

continued as follows: bar, angles and shapes; cast-iron pipes and fittings; sheets under $\frac{1}{8}''$ thick. Before 1914, however, galvanized sheets had moved up into second place, with tinplates fourth and between 1920 and 1930 both of these items exceeded pig-iron in export tonnage. The other commodities retained much the same order, except that thin sheets increased to equal the tonnage of rails and tubes and fittings exceeded cast pipes.

It is apparent that the export of heavy products—pig-iron, rails and structural shapes—decreased, while that of more highly finished products increased. The industry was becoming more of a specialized business weighted on the side of the finishing trades.

In Germany merchant bars, rails and sheets and plates led in importance in 1885 in that order, but gradually the heavier items became increasingly significant so that by 1913 after bars came pig-iron, ingots and billets, plates and black sheets, heavy shapes, rails, in that order. The semi-products decreased, however, after the war as did girders and rails, while sheets, wire and tubes were maintained. On the whole exports did not reach their pre-war level either in value or tonnage. Germany had lost ground on the Continent of Europe, but maintained her position in Britain and the Low Countries, while outside Europe German markets increased.

French exports underwent little change between the pre-war and post-war periods although in tonnage, particularly in crude steel (semis), they increased considerably. Semi-products—blooms, ingots and bars—pig-iron and rails were the leading items. Belgian experience was similar to that of France, the main exports being bars, shapes, angles; plates and sheets; blooms and billets.

From 1896 to 1906 rails were the chief items in American exports, followed by wire and fencing, tubes and fittings, structural shapes, bars, sheets and plates. By 1913 rails ranked after plates and sheets, followed by structural iron and steel and pig-iron. By 1929 rails had dropped to fourth position (a trend common to all exporters), pig-iron was no longer a leading item, while pipes and fittings had increased their relative importance.

Exports of Machinery.

Iron and steel are, of course, the most important constituents of machinery so that the trend of machinery exports throws an additional indication on the progress of foreign trade in iron and steel. British exports of machinery rose steadily from 1870 to 1900 and then more rapidly until 1913. Whilst exports were, of course, much

smaller during the European War, they recovered between 1920 and 1930, although they did not attain the pre-war level as shown in the following table:

TABLE 59

UNITED KINGDOM: EXPORTS OF MACHINERY

Year	*Total* 000 *Tons*	*Value per Ton* £	*s.*	*d.*
1905	545	42	10	0
1910	655	44	10	0
1913	745	49	10	0
1920	460	137	0	0
1925	514	94	10	0
1929	613	96	0	0

In 1913 British exports of machinery were slightly greater than those of Germany, with the U.S.A. closely following, but the value per ton was least in Britain. In 1925 Britain did not export two-thirds the quantity of machinery exported by the U.S.A., nor four-fifths the exports of Germany. This may have been the result of our relative failure in mass production or due to the fact that price, not quality, is the dominant factor in international trade. Both the U.S.A. and Germany exported more metal working machinery than Britain. Exports as a percentage of output and world trade are given below:

TABLE 60

	Output as per cent of World		*Exports as % of World*		*Exports as % of Output*	
	1913	*1925*	*1913*	*1925*	*1913*	*1925*
U.S.A.	50	57·6	26·8	34·8	10	10
Germany	11·8	13·6	28·4	24·4	45	29·8
Great Britain	20·6	13·1	29·0	20·0	26·4	25·3
Others	17·6	15·1	15·0	20·8	16·7	22·1
	100·0	100·0	100·0	100·0	100·0	100·0

MACHINERY EXPORTS

Value per ton

Year	*Britain*	*Germany*	*France*
1913	£49·12	£52·0	£53·0
1924	£94·3	£88·9	£67·5
1930	£96		

Net Exports.

The net iron and steel exports of Britain were the greatest in the world up to 1922, when they were exceeded by Germany. In 1913 the net exports of the countries studied were (000 tons):

Germany	5,800	Belgium	680
Britain	2,750	France	460
U.S.A.	2,550		

During the European War American exports were, of course, the greatest. In 1920–30 British net exports fell away steeply and in fact they were negative for two years (1926 and 1927). After 1925 Belgium had the greatest net exports, followed by France, Germany and the U.S.A.

Exports Per Capita.

The amount of exports per head of population was approximately the same for Britain and Belgium from 1890 to 1900. After that date the figure for Belgium became the highest.

Britain was followed by Germany, then by the U.S.A. and France. In 1920–30 the order was Belgium, France, Britain, Germany, U.S.A.

2. Imports

Britain has long been the largest importer of iron and steel. Before 1870 Belgian girders were being imported, but up to 1885 our principal import was Swedish bar iron. After that date steel blooms and billets were the principal items. In the nineties semi-products were imported from Germany and from the U.S.A., and by 1900 this trend was more marked. In 1904 British imports of iron and steel were three times that of any country in Europe, and between 1904 and 1914 they doubled again.

In 1913 40 per cent of the steel consumed in Britain was of foreign origin, while the production of common grades in this country continuously decreased. Whilst the principal imports into Britain were slabs and blooms, sheet bars and tinplate bars, the principal item of imports into Germany, France, the U.S.A. and Belgium was pig iron. This became again the position after the War, but the competitive strength of the Continental countries, particularly France and Belgium, increased considerably.

In 1927 49 per cent of the steel worked up in Britain was imported, but plates and sheets were imported from Germany in large

quantities. In 1929 we took 20 per cent of German exports and 25 per cent of Belgian exports.

Value of Imports.

It will be noted from the following table that the total value of iron and steel imports increased ten times from 1870 to 1913, and a further 50 per cent between 1913 and 1930.

TABLE 61

UNITED KINGDOM. IMPORTS OF IRON AND STEEL: TOTAL VALUE AND VALUE PER TON

Year	*Total Value* £000	*Value per Ton* £	s.	d.
1870	1,500	10	10	0
1880	4,000	11	12	6
1890	4,500	11	12	6
1900	7,250	9	5	0
1910	9,200	6	12	6
1913	15,800	7	1	0
1920	29,100	26	1	0
1925	24,000	8	17	6
1930	23,300	8	1	0

The average value per ton of British imports fell from 1875 to 1913 and, if corrected for the change in value of sterling, fell during 1921–30 below the value in 1913.

The following table shows how, comparing pre- and post-war years, the average of imports tended to fall below the Board of Trade Index for iron and steel prices, whilst the value per ton of exports was above the Board of Trade Index for all commodities.

TABLE 62

	1913	*1925*	*1927*	*1928*
Iron and Steel				
Value per ton of Imports	100	122	109	118
Value per ton of Exports	100	177	160	152
Board of Trade Index	100	126	120	112
All Commodities: Board of Trade Index	100	160	141	140

Constituents of Imports.

The principal constituents of British imports from 1913 to 1930 are given in Appendix VI, Table 115.

The order of importance of imports in Britain in 1913 and 1929 were as follows:

1913	*1929*
Blooms and Billets	Blooms and Billets
Sheet and Tinplate Bars	Sheet and Tinplate Bars
Iron Bars, Rods and Shapes	Steel Bars, Rods and Shapes
Pig Iron	Plates and Strip
Plates and Sheets	Iron Bars, Rods and Shapes
Steel Bars, Rods and Shapes	Hoops and Strips

The trend of the change in imports may be noted as follows:

Falling	*Rising*
Plates not less than $\frac{1}{8}$ in.	Slabs and Blooms
Plates less than $\frac{1}{8}$ in.	Sheets and Tinplate Bars
Girders and Joists	Wrought Iron Bars
Wire and Wire Rods	Pig Iron
Hoops and Strip	Bars and Shapes
Tyres and Axles	Scrap
Tram Rails	Wire Nails
	Cast Pipes and Fittings

A comparison of the sources of imports of semi-finished and finished rolled products into Britain before and after the War, shows a large increase in semis from Belgium and the establishment of large imports from France (total imports from both countries 1913 507,000 tons, 1928 1,902,000 tons), while there was a fall in imports from Germany and the U.S.A. (total imports from both countries 1913 1,279,000 tons, 1928 363,000 tons).

(*d*) The Trend of Steel-Making Processes

It has been pointed out above, when considering Continental competition with British steel, that we are not necessarily comparing like with like, as the greater part of Continental output has been of Thomas (basic Bessemer) steel, whereas British steel, up to 1913, was mainly made by the acid open-hearth process.

Bessemer and open-hearth steels are two distinct products in quality and in price, and the differences between these two classes of steel are brought out in the following consideration of steel making processes:

1. Converter Steel

Table 69 shows the production of converter steel in the countries under comparison from 1870 to 1930. It will be noted that this period saw the rise and fall of converter steel in Great Britain and the somewhat similar course pursued in the U.S.A., but with a

TABLE 63

PRODUCTION OF CONVERTER STEEL (000 TONS)

Year	Britain		U.S.A.		Germany		France		Belgium	
	Total	Basic	Total	Basic	Total	Basic	Total	Basic	Total	Basic
1870	215	—	37	—	—	—	—	—	—	—
1875	619	—	335	—	—	—	—	—	—	—
1880	1,044	—	1,047	—	697	18	—	—	—	—
1885	1,303	—	1,519	—	926	548	—	—	—	—
1890	2,014	402	3,688	—	1,843	1,493	432	—	—	—
1895	1,534	441	4,909	—	2,835	2,520	500	—	—	—
1900	1,744	491	6,684	—	4,364	4,142	919	—	540	540
1905	1,973	577	10,941	—	6,627	6,204	1,482	1,350	1,095	1,095
1910	1,779	641	9,412	—	8,201	8,031	2,241	2,136	1,755	1,755
1913	1,599	551	9,545	—	10,785	10,630	3,058	2,806	2,192	2,192
1920	820	268	8,883	—	3,264	3,220	1,716	1,656	973	973
1925	475	28	6,723	—	5,132	5,111	5,253	5,175	2,183	2,183
1930	255	—	5,035	—	5,136	5,136	6,685	6,569	3,500	3,500

(Blanks do not mean that there was no production but absence of data.)

time-lag of about fourteen years. In Germany converter steel production increased up to 1913, but after the European War did not recover much above half the 1913 peak figure. In France and Belgium steel production in the converter increased throughout the period.

The next point brought out is that basic converter steel took no hold in Britain and the U.S.A., whereas it constituted practically the whole of the converter production in Germany, France and Belgium. The course of converter steel production represented as a percentage of the total is expressed in the following table:

TABLE 64

PERCENTAGE OF CONVERTER STEEL

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1875	86	—	—	Practically 100	—
1880	80	91	—	,,	85
1885	76	—	—	,,	—
1890	57	83	63	,,	—
1895	47	70	57	,,	78
1900	35	65	58	,,	66
1905	34	66	66	,,	55
1910	28	60	66	,,	36
1915	15	50	—	,,	26
1920	9	35	57	,,	21
1925	6·5	42	70	,,	15
1930	3·5	44	70	,,	12

It will be noted that the Continental countries which retained a large percentage of converter steel in their production did so by developing the basic process (Thomas steel works).

The basic process (depending on a basic lining) was of course applied to the open-hearth furnace as well as to the Bessemer converter, but we may note in passing a general prejudice against basic steel in Britain, as illustrated by the following figures of total production by all processes between 1878 and 1890.

	Basic Steel	*Acid Steel*
Britain	2,720,000 tons	25,194,000 tons
Continent of Europe	10,666,000 tons	20,705,000 tons

The production of basic steel first exceeded acid steel in Germany, France and Belgium about 1890, in the U.S.A. by 1908, but in Britain not till 1919. England clung for a time to wrought iron

instead of steel, and also to acid steel instead of basic. This concentration on acid steel by Britain was destined to prove a handicap during the War.

As regards converter steel, the prejudice was not there at first as the International Rail Manufacturers' Association quoted equal prices for basic and acid rails. Unfortunate technical incidents, however, led English engineers to refuse to specify basic Bessemer steel. The trouble was due to lack of application by English steel makers to the difficulties in the process, whereas considerable improvements in technology abroad increased the uniformity and advantages of this class of steel. It may be noted that committees appointed by the British Iron Trade Association visited the Continent in 1894 and also 1904, and were very impressed by the German and Belgian Thomas steel plants and steel-making practice. Not only was basic Bessemer steel cheaper but it had more uses.

The question of the economy of basic Bessemer steel was not, however, a simple one. Although it had the advantage of greater over-all fuel economy, factors such as the relative value of scrap and pig iron and the selling price of basic slag had to be considered, and native British ores were more suitable for making open-hearth than Bessemer steel. While the erection of Bessemer plants would have involved heavy capital expenditure, the output was higher as judged from the following figure:

Weekly output of a British converter in 1896	1,500 tons
Weekly output of a British Siemens furnace in 1900	400 tons

English authorities (Harbord, Carnegie) had, moreover, shown that basic Bessemer steel could be made here from 7s. to 10s. per ton cheaper than basic open-hearth steel.

As regards uses, basic Bessemer steel is more suitable for re-rolling into wire rod reinforcement bars and tube strip. Other advantages and disadvantages are given in Table 65.

The neglect of the Thomas process by Britain, as the result of which the industry drifted away from the centres of cheap steel production, is all the more surprising, as for many years large and increasing quantities of basic Bessemer steel were being imported, and, of course, in export trade quality differences were of no appreciable importance. What was required was the setting up by 1890 of Thomas plants in Lincolnshire or Frodingham, but it was not till after the period under review closed that the Stewart and Lloyds plant at Corby was erected.

TABLE 65

BASIC BESSEMER PROCESS IN BRITAIN

Advantages	*Disadvantages*
Lower fuel cost	Control not so close and quality not so high in open-hearth furnace
Lower labour cost	
Faster speed of production	A lower yield of ingots 80 to 88 per cent compared with 100 per cent for open-hearth practice;
Lower capital cost per ton	
Regular delivery of ingots in relatively small quantities (15 mins. per cast against 8 hours for open-hearth furnaces)	As all the blast furnace gas cannot be used, and no coke-oven gas is required, a gas grid is required to prevent waste
Credit for basic slag	While British ores were high enough in phosphorus, it was doubtful if they were regularly low enough in silicon and sulphur

2. Open-Hearth Furnace Steel

The growth of open-hearth steel production in the five countries is given in Table 66.

The percentages of the total constituted by basic steel was:

Year	*Britain*	*U.S.A.*	*Germany*	*France*	*Belgium*
1900	9	75	94	100	100
1930	75	98	99	100	100

indicating the relative slowness of development of basic open-hearth steel in Britain. On the other hand, the total open-hearth steel made constituted a much larger proportion of the toal production in Britain than in the other countries, as shown in Table 67.

After the construction of the first open-hearth furnaces in Britain development tended to lag behind German and American practice in capacity and fuel consumption. By 1890 the average capacity of open-hearth furnaces in Britain was 10 tons, against 15 tons in Germany and 30 tons in the U.S.A., and the average life of furnaces in Britain was twice that in Germany. In 1930 the average size of furnace was 55 tons, against 80 tons in the U.S.A., where large tilting furnaces had been introduced. The average annual output per furnace was as follows:

Year	*Britain* *Tons*	*U.S.A.* *Tons*
1900	10,000	40,000
1930	25,000	70,000

TABLE 66

OPEN-HEARTH STEEL PRODUCTION (000 TONS)

Year	Britain		U.S.A.		Germany		France		Belgium	
	Total	Basic	Total	Basic	Total	Basic	Total	Basic	Total	Basic
1875	88	—	8	—	—	—	—	—	—	—
1880	251	—	100	—	36	—	—	—	—	—
1885	583	—	133	—	276	—	—	—	—	—
1890	1,564	101	513	—	388	—	251	251	—	—
1895	1,724	165	1,137	—	1,189	—	376	376	—	—
1900	3,156	280	3,398	2,545	2,146	1,998	646	646	—	—
1905	3,837	795	8,971	7,815	3,252	3,087	756	756	105	105
1910	4,594	1,578	16,504	15,292	5,114	4,974	1,137	1,137	137	137
1915	7,048	2,958	23,679	22,308	5,671	5,423	967	967	27	27
1920	7,984	4,682	32,671	31,375	5,615	5,541	1,207	1,207	219	219
1925	6,712	4,744	38,034	37,087	6,625	6,475	2,103	2,103	291	291
1930	6,852	5,091	35,048	34,268	6,042	5,936	2,596	2,596	400	400

(Blanks do not indicate nil production but absence of data.)

TABLE 67

OPEN-HEARTH STEEL: PERCENTAGE OF PRODUCTION

Year	*Great Britain*	*U.S.A.*	*Germany*	*France*	*Belgium*
1875	12 5	—	—	—	small
1880	19·3	—	4 9	—	,,
1885	31 0	—	23·0	—	,,
1890	43·6	—	17·4	36 8	,,
1895	52·9	—	29·6	43·0	,,
1900	64·3	33·4	32·2	42 0	,,
1905	66·2	44·8	32·4	33 6	,,
1910	72·1	63·2	37·3	33·4	,,
1913	79·2	69 0	40·2	33·8	,,
1920	88 1	77·4	60·6	40·9	,,
1925	91·0	83·8	59·2	28·2	,,
1930	94·3	86·0	52·3	27·5	,,

The largest open-hearth furnaces in Britain were on the north-east coast, which district was the largest steel producer in 1913 and 1930.

Open-hearth furnaces favoured small plants, which suited the British works. One of the reasons given for the use of small furnaces was the greater exigencies of users of British steel, but it is evident that no attempt was made in Britain to take advantage of high capacity melting or (as will be shown later) rolling.

The use of small furnaces duplicated labour and caused higher fuel and other charges. The larger hearths and shallower baths in foreign practice gave a larger number of casts per working week, and on these larger units more mechanical charging and handling equipment was used.

It is evident that Britain was not in a position to manufacture large quantities of ordinary steel and the chronic instability of the production of common grades is understandable.

Bessemer and Open-Hearth Costs.

The following table shows the percentage distribution of cost in making open-hearth and Bessemer steel in the U.S.A. in 1918.

It will be noted that the cost per ton of Bessemer steel was the lower and the wages cost only 3 to 5 per cent as compared with 4 to 6 per cent for open-hearth steel. The fuel cost was 0·65 to 3·3 per cent against 4·6 to 6·7 per cent for open-hearth steel.

One of the reasons for the development of open-hearth steel in Britain was the possibility of using a high proportion of scrap in the charges. In acid open-hearth practice it was about 75 per cent

TABLE 68

Average cost per gross ton at furnace of Open-hearth Ingots for specified groups of Steel Companies, JUNE-DECEMBER 1918

Federal Trade Commission

Item	*Class I Steel Companies*			*Class II Steel Companies*			*Class III Steel Companies*			*All-Steel Companies*		
Production (tons)	13,420,893			1,135,227			2,195,245			16,751,365		
		per cent			*per cent*			*per cent*			*per cent*	
Net metal	$26·30	79·1		$31·10	75·5		$33·93	73·5		$27·62	78·0	
Fuel	1·54	4·64	84·7	2·27	5·5	82·3	3 12	6 75	82·1	1·79	5·04	84
Fluxes	0·33	0·99		0·56	1·36		0·84	1 81		0·41	1 15	
Labour	1·43	4·27		2·60	6·32		2·56	5 62		1·66	4 68	
Maintenance and repairs	1·15	3·46		1·25	3·15		2·21	4·78		1·30	3·66	
Moulds and stools	0·38	1·14		0·66	1·6		0·93	2·01		0·47	1·32	
Relining and renewals	1·05	3·16		1·08	2 62		0·80	1·73		1·02	2·88	
Other furnace costs	1·10	3·31		1·75	4·24		1·86	4·0		1·25	3·52	
Credits	0·06	—		0·03	—		—	—		0·05	—	
Furnace cost	33·22	—		41·24	—		46·23	—		35 47	—	
Index	100	—		124	—		139	—		—	—	

Average cost per gross ton at furnace of Bessemer Ingots for specified groups of Steel Companies, JUNE–DECEMBER 1918

Production (tons)	5,288,953			112,930			144,927			5,546,810		
Net metal	$27·12	90·1		$32·06	85		$37·03	87·5		$27 48	90 8	
Fuel	0·18	0·65	90·8	1·25	3·31	88·5	0·72	1·7	89·3	0·21	0·89	91
Fluxes	0 01	—		0·07	0·19		0·03	0·71		0·01	0·03	
Labour	0·97	3·24		1·58	4·2		1·96	4·64		1·00	3·3	
Maintenance and repairs	0·56	1·87		0·76	2·0		0·97	2·29		0·57	1 88	
Moulds and stools	0·22	0·74		0·65	1·72		0·78	1·84		0·25	0·82	
Relining and renewals	0·04	—		—	—		—	—		0·04	0·013	
Other furnace costs	0·71	—		1·30	—		0·86	—		0·73	2·91	
Furnace cost	29·81	—		37·67	—		42·35	—		30·29	—	
Index	100	—		126	—		142	—		—	—	

and in basic open hearth 60 per cent. In the U.S.A. and Germany the scrap used was about 50 per cent of the charge.

As the greater part of the steel produced in Britain since 1895 has been open-hearth steel, it will be seen that the industry was engaged in remaking, not making steel.

3. Electric Furnace Process

The third principal method of steel manufacture, viz. in the electric furnace, did not commence until a few years before the European War. Production by the countries under consideration are given in the following table:

TABLE 69

Production of Electric Furnace Steel (000 tons)

Year	*Great Britain*	*U.S.A.*	*Germany*	*France*	*Belgium*	*World*
1910	—	55	36	13	—	—
1913	—	—	—	—	—	189
1915	22	79	132	39	—	—
1918	120	—	—	—	—	1,149
1920	89	500	85	67	—	—
1925	64	720	126	74	—	—
1929	—	—	—	—	—	1,109
1930	76	615	139	153	14	—

A rapid increase occurred between 1914 and 1918, due to the practice of melting the large accumulations of alloy steel scrap and turnings. After the war there was a severe slump in production and recovery was very slow.

Its importance is, however, out of all proportion to its volume relative to the two older processes, as high quality steels can be made in the electric furnace at approximately half the cost of crucible melted steel, the method previously employed for the highest grades.

The U.S.A. was the largest producer after 1916, and the output between 1920 and 1930 was greater than that of Europe. The lead in Europe was taken by Germany in 1909, electric furnaces being developed up to 30 tons capacity for the re-fusing of basic Bessemer steel. After the war Germany also recovered the premier position in Europe. France made an earlier start than Britain, the French output being the greater up to 1913 and from 1925 to 1930.

Electric furnace steel did not develop as fast in Britain as in the other leading steel-producing countries, nor did it attain the same proportion of the total output. This was partly due to the relatively

higher cost of electric power and partly due to traditionalism and caution where new processes were concerned. During the war, however, many furnaces were built and the capacity in 1920 was said to be about 300,000 tons. On Tyneside in particular, where cheap power was obtained from coke-oven gas, electric steel was reported to be made as cheaply as acid open-hearth furnace steel.

4. Crucible Steel Process

In Britain the peak of crucible steel production was reached in 1881 with about 100,000 tons. It declined to 42,500 tons before the war and was only 13,000 tons or less in 1920–30. The maximum production in France of 42,000 tons occurred in 1918, and in Germany of 130,000 tons occurred in 1917. In the U.S.A. crucible steel production attained 100,000 tons in 1899 and remained above this figure until 1918, after which date it fell off rapidly. The crucible steel process is limited to small-scale production and was bound to decline as steel of as high quality could be made more rapidly in electric furnaces.

(*e*) Fuel Economy in Steel Works

In Chapter IV it was pointed out, in dealing with blast furnace practice, that fuel economy must be considered in its overall results throughout the process of iron and steel making and working. There is no economy in being efficient at one stage if the advantage in fuel consumption is lost at another.

It has been noted that in blast furnace fuel economy, no advance was comparable with Neilson's invention of the hot blast unless perhaps the substitution of by-product for beehive coke, and British metallurgists may also be said to have led the way in fuel saving in the manufacture of steel, as from this point of view the invention of the converter has probably not been excelled. From 1856 to 1880 the brothers Siemens also applied in this country the regenerative principle to open-hearth furnaces, giving the cardinal principle of fuel economy to the chief British and American method of steel manufacture.

Fuel economy in steel works depends on (1) the use of coke oven and blast furnace gases, (2) the avoidance of heat losses between stages of production.

The reasons for the proximity of coke ovens, blast furnaces and steel works are different in the case of open-hearth and Bessemer steel works. Open-hearth works must be near cokeries as 4 or 5 cwt.

of coal are consumed per ton of steel, whilst Bessemer works must be near blast furnaces and no fuel is required.

Unfortunately the British iron and steel industry laboured under the disadvantage of having most of its works established before 1880, whereas those in other countries could be laid out with the advantage of the experience gained. In his presidential address to the Iron and Steel Institute, 1927, Harbord said, "Complete open-hearth plants with coke ovens, blast furnace, mills, etc., did not exist in 1890, or at all events were not erected as complete plants."

The heat and power requirements in a steel works include the mixer, the steel plant, the auxiliary plant, the soaking pits and rolling mill power. In a well-balanced plant there is no need for solid fuel except in the blast furnaces, as there is a theoretical excess of heat above steel works requirements in either Bessemer or open-hearth works. In the latter the margin is not, however, great, and attention must be given to the storage of power and gas in steam accumulators and gasometers.

Fuel economy is one of the factors leading to vertical integration, and foreign industries had, on the whole, an advantage, in view of their greater degree of concentration and organization. Continental industries further profited from the fuel point of view by the establishment of basic Bessemer steel works.

In 1916 Professor Bone calculated that a ton of finished steel sections from Cleveland ironstone and Durham coke could be manufactured from not more than 35 cwt. of coal in the coke ovens and it was considered that no more than this quantity of coal per ton of finished steel sections was warranted for a modern British plant. In 1919, however, the total coal consumption from the iron-making stage in the Cleveland district was 40 to 45 cwt., including 10·0 to 12·5 cwt. of coal per ton of finished steel sections. Whilst fuel consumption in an open-hearth steel works depends on the type and size of the furnace, the character of the metal produced, the proportions of molten and cold charge, the type of section finally rolled, as well as on other factors, the possible economy which would have been effected at the time was found to be 5 to 10 cwt. of coal and in Lincolnshire it was considerably more.

Fuel consumption in steel works in other countries decreased steadily. In the U.S.A. the average ratio of coal used to a ton of steel products diminished as follows:

1904	2·01
1914	1·83
1927	1·41

In Germany the average consumption of heat per ton of Siemens Martin steel was decreased by three-fifths between 1870 and 1900. In the basic Bessemer works the steel plants used only coke oven and blast furnace gas, with a surplus, which was sold outside the plant.

In Britain few works were modern throughout with coke ovens, blast furnaces, steel furnaces and rolling mills adjacent to each other and making a full use of waste gases. A higher proportion of iron and steel was allowed to cool compared with foreign practice and few, if any, rolling mills were electrically driven with power raised from waste gases. Several authorities have, in fact, put on record that many of our steel works were working with a definitely higher fuel consumption than our Continental neighbours, thereby adding to the steel-making costs.

Scientific management and control of the whole heat economy in the works was required, and though some British works were organized by 1930 on these lines, there was a scarcity in this country, even during the decade 1920–30, of adequately trained fuel experts in iron and steel works. Much was done to help the industry in fuel economy by the Fuel Department of the N.F.I.S.M. and the Fuel Section of the F.B.I., but in Germany scientific study of the subject was commenced earlier by the establishment of Warmestelle and fuel technologists were employed in a larger proportion of works.

The heat consumption per ton of crude steel made falls with an increasing load factor. After 1921 the British steel industry was running at a fraction of its capacity—rarely above 60 per cent—which was a further factor in the fuel efficiency being lower than on the Continent, where plants had been working more nearly up to capacity. The smaller size of the average British plant further militated against the full recovery of waste heat.

It was recognized that entirely new and fully integrated steel plants in Britain were desirable with full technical integration comprising coke ovens, blast furnaces, steel works and rolling mills, in contrast with those which had grown from gradual evolution. The problem, however, was to raise the money for the reorganization necessary for fuel economy in the existing works, let alone that required for new plants.

In short it appears from the above that the general problem of the size and balance of iron and steel-making processes and steel working, had not, prior to 1930, been solved in Britain to the same extent as in competitive countries.

(f) Rolled Steel Products; Castings and Forgings

Semi-Products

Semi-products consist of blooms, billets and slabs, the result of the first reduction of steel ingots, and differentiation to any marked degree does not start till after the semi-product stage.

In a fully integrated steel plant the semi-products are carried straight forward to the finishing rolling mills. This procedure was not, however, characteristic of the British industry, in which about one-third of the semi-products—more than in Germany or the U.S.A.—were despatched to re-rollers for finishing.

Total Production

The total production of finished rolled steel products by the countries under comparison is given in the following table. It will be noted that the U.S.A. early attained the lead and that Germany surpassed Britain soon after the beginning of the century. At the end of the period France also had surpassed Britain.

TABLE 70

Total Production of Rolled Steel Products (000 tons)

Year	*Great Britain*	*U.S.A.*	*Germany*	*France*	*Belgium*
1890	—	6,000	1,500	500	—
1895	—	6,000	2,500	1,500	—
1900	—	9,500	4,300	2,000	—
1907	4,800	19,700	—	1,800	1,300
1910	—	21,600	8,900	2,300	1,700
1912	5,600	24,500	—	3,000	1,900
1920	6,700	32,300	6,300	—	1,100
1925	6,400	33,300	8,400	4,800	1,900
1930	6,120	29,500	8,150	6,510	3,121

In Appendix VI outlines and tables are given of the history of the output of the leading rolling mill products—merchant bars, structural shapes, rails, plates and sheets, galvanized sheets, tinplates, wire rods and tubes—in the countries under review.

Castings.

Castings constituted a small proportion of British production, but one of high value, of which Sheffield produced over 40 per cent. Although castings were exported as part of machinery, there were appreciable exports from Belgium and Germany, and before the

end of the period there was evidence that British technique needed improvement in some directions.

Forgings

The production of steel forgings involves the use of heavy and costly plant and presents technical rather than economic problems. The output was somewhat less than that in Germany but greater than that in France. The British plants were rather obsolete and concentration of production could have been carried out with advantage.

Rolling Mill Technique

The early start of the British steel industry gave certain technical advantages, but on the other hand, the re-rolling industry developed with, and was based on, the iron industry and was economically unsound for steel and by 1900 there were indications that our rolling mill practice was no longer in advance of some other countries. In a report of the Iron Trade Association in 1894 special mention was made of the fact that German sheet and wire mills were working at a lower cost. At the same time comment was made on the more general use and labour-saving significance of electricity in steel works in the U.S.A. than in this country. Before 1914 it was evident that the rate of increase in output in our plants was not as fast as in America and some Continental countries, although there was a definite increase in the output of British rolling mill plant as electrification progressed for driving and controls. Specialization in high output rolling mills on the Continent reduced their billets costs compared with British billets, which were rolled in merchant mills. This also applied to bars, strips and hoops, which on the Continent were rolled direct from the ingot, the power being generated from waste gases. In the U.S.A. also rolling practice was more efficient than in Britain, due to better equipment and a better system of mill operation. The automatic American machinery minimized the number of men required and sheet rolling underwent a revolution by the introduction of the continuous rolling mill. The greater degree of mechanization in the U.S.A. is illustrated by the following figures for total primary power in the iron and steel industries.

Million Horse Power

	1907	*1914*	*1924*
U.S.A.	2·90	3·92	6·0
Great Britain	1·38	1·42	1·75

In 1924–25 the h.p. per worker was 12·85 in the U.S.A., compared with 9·15 in Great Britain.

In the production of rolled products vertical organization is important. Concentration and continuity of production is essential as frequent changes of rolls is uneconomical. Continuity depends largely on standardization of sections and this did not proceed as fast in Britain as abroad; in rails, in particular, full economies can only be achieved in large-capacity mills. There were a few efficient plants for plates in Britain, but rolling mills were not, on the whole, favourably situated and contact with shipbuilders should have been closer. The wire rod industry needed concentrating in large-scale production units. Even in tinplate production the British makers considered first cost most important, though wastes might be high, and relied on tradition and experience rather than research; e.g. in coating systems, firing pots, etc. Plants for making tubes and pipes were scattered and there was a lack of technical co-ordination of processes. The production of strip was not developed.

A comparison of costs on the Continent, Britain and the U.S.A. indicated that the labour percentage of the total rolling mill cost was in inverse order to the wage level. It may therefore be considered that the way to reduce British labour costs would have been to increase the technical efficiency of the plant. Whilst in the most modern British mills our costs for ship materials and bridge work, for example, could not have been far different from those of the Continent, the majority of plants, being constructed in the 19th century, were not of the highest efficiency. Instead of a number of mills rolling the same product, a few, if specially designed, could have taken care of the whole British trade in one commodity. The existence of old-fashioned plant had long been appreciated and the necessity for reduction and concentration, especially in the heavy industry, but the principal difficulty was the lack of funds for modernization, especially after the War. The German heavy steel undertakings were built on a large scale for technical reasons, apart from the general trend towards combination and mergers. In this country the heavy steel industry was undoubtedly the weak link in the chain of processes, and the chief means of reduction of working costs would have been by standardization of products and the installation of high output units, which would have secured a larger output with lower fuel consumption per ton.

(g) GROSS PRODUCTIVITY OF STEEL WORKERS

It has been noted above that the pig iron production per man employed in Britain was lower than in competitive countries. Similar information for the steel industry is more difficult to ascertain owing to lack of data on the number of workers engaged in specific phases of steel production. In the U.S.A. information has been given in the form of index numbers in tons per man per year, and in the case of Germany, France and Belgium some figures are available on the number of workmen engaged in the production of steel ingots and castings, and approximate indices have been worked out and are given for what they are worth.

TABLE 71

STEEL OUTPUT PER MAN

Approximate Index Number

1910 = 100

Year	*U.S.A.*	*Germany*	*Belgium*
1900	65	60	45
1905	72	77	70
1910	100	100	100
1915	124	95	—
1920	108	53	—
1925	112	102	120
1927	138	168	153

In Britain, however, the employees are grouped together for steel making and rolling so that productivity expressed in ingot production cannot be calculated.

Even if comparative figures were available, they could not be strictly interpreted as a measure of productivity owing to differences in practice and methods of manning steel furnaces. Much depends on whether the steel is made in open-hearth or converter furnaces, whether the iron is charged direct or not, the size of the furnace and quality of the steel being made, the plant lay-out and correlation of the various stages in steel making, as well as other factors. In any country the output per establishment and per workman shows its wide variations. In a general way, however, there is some evidence that the output per worker increased in all countries from 1870 up to 1913, fell during the War and increased again after 1921 to higher levels than before. Gross productivity was probably highest in the U.S.A., being due to the greater degree of mechanization and amount of power available per workman. It was next

highest in Germany, where employees diminished, although the output increased. The output per man in Belgium approached that of Germany and was somewhat ahead of France, a rapid increase between 1920 and 1930 being clearly shown.

The output per man in Luxembourg in 1927 was said to be greater than in Britain by about 40 per cent for semi-finished steel, and 16 per cent for finished steel.

The relative position of Britain is difficult to express: there were more workers in the steel industry than in France, but the outputs were about equal; British production was twice that of Belgium, but the number employed was decidedly more than double; steel production in Germany was 50 per cent higher than in this country, but there were hardly any more workers in the industry.

The following comparison is given in Eisenerzeugende Industrie of productivity (output per man per year) in steel melting and rolling:

TABLE 72

GROSS PRODUCTIVITY IN STEEL MELTING AND ROLLING

Year	*Great Britain* *Tons*	*Germany* *Tons*	*Belgium* *Tons*
1913	—	77	—
1920	48	—	—
1922	37	—	—
1923	45	—	—
1924	49	60	—
1925	49	73	66
1926	—	92	—
1927	52	101	—
1928	52	93	—
1929	58	96	98

Allowing for differences in methods of steel production it appears, on the whole, that the average gross productivity in Britain was relatively low. This is not unexpected in view of the smaller size of producing units, the less degree of integration of stages in steel production, the greater average age of the equipment and the somewhat shorter working hours. On the other hand, 1913 output was regained with fewer workmen, so that productivity in this country definitely increased in post-war years.

Productivity depended so much on capital investment, methods of production, organization and management, that a considerable reduction of the number of men required and a greater output per

man per shift could only be achieved by means of large-scale, well-balanced plants, producing steel on the most advanced technical lines. In Britain this requisite was lacking in the case of ordinary grades of steel and semi-finished products. In higher grade steels reduction of costs from an extreme division of labour and improved factory organization was less applicable, and the output per man abroad did not exceed the British figure.

(*h*) Wages

It has been noted above that wages in pig iron production rarely amount to 10 per cent and at any given stage of steel making the wages paid also constitute a small item,* though the accumulative wages up to the finished steel product form the greatest single component of the costs. For finished rolled products wages form from 20 to 30 per cent of total cost, excluding transport.

TABLE 73

WAGES IN THE IRON AND STEEL INDUSTRY

1879–89

Year	*Wages*	*Great Britain*	*Germany*	*U.S.A.*
1879–80	Per shift	3/10	2/9 to 3/7	—
1883	Average per day	5/0	2/8	8/9

1874: Daily Wages in Steel Working Shops

Country	*Fitters and Lathemen*	*Blacksmiths*	*Strikers*
U.S.A.	8/6	8/9	5/6
North of England	5/1	5/5	3/4

1875–78: Daily Wages in Steel Working Shops

Country	*Fitters and Lathemen*	*Blacksmiths*	*Strikers*
Great Britain	4/6	4/9	3/1½
Germany	3/– to 3/6	3/4	2/6
France	3/6 to 4/6	3/9	—
Belgium	3/6 to 4/6	3/2 to 3/11	3/2

1888–89: Hourly Wages

	British	*Continental*
Blast Furnace	2½d. to 4½d.	2d. to 2¾d.
Bar Rolling	5d. to 7d.	3½d.
Open-hearth Melting	5½d. to 10d.	2¾d. to 3½d.
Rails	6d.	2½d. to 4¾d.

* Data for U.K., U.S.A. and Germany are given in the Appendix Table 125.

Owing to the many grades of skilled and unskilled workmen in each section of the steel industry, it is not possible to compare labour costs except in a general way. The position as regards steel workers has, however, been much the same as that outlined above for iron workers, viz., Britain has paid lower wages than in America and higher than on the Continent.

In the seventies and eighties steel workers were paid approximately 50 per cent more here than in Western Europe, but less than in U.S.A., as exemplified by the following figures for converter men, given by Sir Lowthian Bell.

Other British steel makers besides Bell expressed concern regarding wage rates, and it was appreciated that lower Continental wages could only be counteracted by the possession of better plants.

In 1890 the average wage per shift was as follows for Bessemer steel works:

	Cleveland	4/8	Germany	4/1½	Belgium	2/9
or say	Britain	100	Germany	88	Belgium	59

A report by the United States Commissioner of Labour in the same year showed that the average annual income in the same groups of steel makers was in the following order: U.S.A., Britain, Germany, Belgium, and that the higher wages in Britain were not often offset by increased productivity, although in the U.S.A. they were. In Belgium it was considered that productivity was lower. As will be noted later, the working hours of steel workers were about the same in the different countries. (Report by British Iron Trade Association, 1895.)

In 1906 the Board of Trade enquiry into earnings and hours of labour in the metal industries gave the following figures for average shift wages in Britain and Germany.

Year	*British Wages*	*German Wages*	*Ratio per cent*
1888	4/8	3/11	84
1890	5/–	4/1½	83
1900	7/3	5/–	69
1904	6/–	5/1	84
1906	6/3	5/7	89

In Germany, however, welfare schemes became operative in the nineties which, together with State Insurance charges, amounted to about 1·2 per cent of wages.

The matter was, of course, complicated by district rates and contract working, and it was noted that in both countries districts

of low wages were the least efficient. The point brought out was that though the British wage was higher, the productivity of the German worker was equal to that of the British and this was considered to be due to the greater mechanization in Germany

American competition at this time showed that mere money wages were no criterion of labour costs, which were principally reduced by

TABLE 74

AVERAGE WAGES IN THE IRON AND STEEL INDUSTRY (£)

Year	*Great Britain*	*U.S.A.*	*Germany*
1895	76	—	52
1900	—	90	68
1905	—	100	76
1910	92	114	85
1914	100	120	90
1922	145	245	—
1925	154	257	120
1927	154	255	135

large-scale mechanized production. Further illustrating the relative unimportance of wage rates as such, Belgian semi-products were being sold at a price less than the British wages per ton.

In 1909 British wages were 10 per cent above corresponding rates in Westphalia and 20 per cent above those in the Saar and Lorraine. After the War the eight-hour day became general in Britain, operating as an effective rise in wages. It should also be noted that

TABLE 75

1913–26. AVERAGE WAGES PER SHIFT IN THE IRON AND STEEL INDUSTRY IN VARIOUS COUNTRIES

(*Iron Age*, 21.7.1926)

	1913 (10 to 12-hour)			1926 (8-hour)		
Country	*Dollars*	*Shillings*	*Index (United States)* = 100	*Dollars*	*Shillings*	*Index (United States)* = 100
U.S.A.	2·85	11/8	100	(*a*) 5·82	24/–	100
U.K.	1·80	7/6	63	2·45	10/–	42
Germany	0·85	3/6	30	1·36	5/2	23·5
France	1·20	5/-	42	(*b*) 1·35	5/1	23
Belgium	1·05	4/4	37	0·98	4/1	17

(*a*) All works employees of the U.S.A. Steel Corporation.
(*b*) For 8 hour: actual shift 10 to 12 hour.

Further data are given in the Appendix, Table 125.

the wages of the lower rated men were increased more than those of the higher rated men.

Average annual wages in the iron and steel industries of the U.S.A., Britain and Germany from 1895 to 1927 are given in Table 74, showing that they have been in the order named for the last thirty years.

In 1914, before the outbreak of the European War, the wages per shift were in the following ratios: U.S.A., 100; United Kingdom, 63; Germany, 42. In France and Belgium the index numbers were lower, 37 and 30. In 1926 the corresponding figures for an eight-hour shift were 100, 42, 23, 23 and 17. For the same year the actual earnings per shift of various categories of steel workers are given in Table 75.

The higher weekly wages of workmen in this country compared with European wages is shown by the following for 1927.*

Workman	*England*	*Germany*	*Belgium*
Unskilled	58/5 to 66/9	39/7	25/10
Transport		40/7	29/3
Skilled		52/2	41/8
Steel Wire Drawers		54/2	41/8
Steel Mill Roller		57/3	43/–

* *Iron Age*, 7.4.27.

An idea of the relation of American to British wages in the same year (1927) may be obtained from the following eight-hour shift payments in tinplate mills.

Workman	*U.S.A.*	*South Wales*
Roller	54/6	24/3
Catcher	26/11	19/7
Doubler	26/3	18/9
Heater	34/10	17/6
Shearman	34/2	22/2
Tinner	28/–	16/8
Branner	21/7	8/2
Labourer	14/5	7/4

In 1930 the average weekly wages in France and Belgium were about one-half, and in Germany about three-quarters, of those in Britain, the figures for skilled, semi-skilled and labouring workmen in the steel industry being shown in Table 76.

Labour costs did not, however, vary nearly as much between the different countries as wages did.

TABLE 76

	Average weekly wage			*Average all*
	Skilled	*Semi-skilled*	*Unskilled*	*Workers*
England	139/7	78/7	49/2	67/3
France	51/6	40/3	32/2	37/0
Belgium	63/9	38/10	30/10	35/-
Luxembourg	49/2	38/10	32/-	36/7
Germany	68/6	52/10	47/-	50/11

It should be noted that a good number of foreign workmen were being employed in France and Belgium at the time.

Competition in semi-finished products and other mass produced forms of steel arose chiefly from the European countries with low wage levels, but this was not the cause of their intensive post-war underselling of British steel as the relative position of wages remained much the same throughout the whole period reviewed. It was due, in as far as labour costs were concerned, to the output per man employed in Britain not increasing proportionately with those of our competitors.

In countries where the traditional level of wages is high, as in the U.S.A., this can only be maintained by superior efficiency. This is illustrated by the heavy capital expenditure in the U.S.A. on plant, designed for labour-saving and continuous production: between 1924 and 1928, for example, $150 millions were spent on modernizing works. Wages increased during that period but cost fell appreciably, as shown by the following figures:

Operation	*Wages increased*	*Costs decreased*
Relining Open-hearth Ladles	21·3 per cent	14·4 per cent
Soaking Pits	19·0 per cent	20·4 per cent
Track Repair	25·0 per cent	34·0 per cent

In Germany after 1923 wages increased appreciably but were largely offset by the economies of rationalization and modernization of plant, which reduced the number of workmen required for a given output.

The high labour cost in Britain did not appear to be the fault of the workmen, who were frequently charged with a traditional pace of working, as in many processes in the iron and steel industry the output per man is beyond their control, the pace of production being set by the plant. If wages were the only way of dealing with the situation, they would have had to receive drastic treatment in Britain, possibly being halved. There were, however, more practicable alternatives, though they would have meant the employment of

fewer workmen—certainly for a time, possibly for all time. By a more scientific location and lay-out of works, modernized plant integration and rationalization of the various branches of the steel industry, productivity could have been increased and unit labour costs considerably lowered. Without carrying specialization of plant for large-scale output so far as in the U.S.A., a great deal could have been done to increase the average productive power of British labour.

(*i*) Transport Costs in Steel Productions

The immense size of steel producing units and the weight and bulk of materials make the industry particularly sensitive to the effect of transport costs, both in assembling the raw materials and distributing the final product. In Appendix vi, Table 127, a comparison of home and foreign rates per ton-mile for pig iron and manufactured iron shows that in 1884 railway rates were higher in Britain than in the U.S.A. and even than in Europe.

In 1894 British rates to ports for finished iron and steel were two or three times those in Belgium.

e.g. Belgian Works to Antwerp	0·51d. per ton-mile
Staffordshire to Ports	1·06–1·41d.

It may be stated that for long distance traffic Continental freight rates were at most one-half those charged in Britain.

In the post-war years British rail charges were increased and the following table illustrates the increase that occurred in comparison with 1914 on one particular line:

TABLE 77

Assembly Costs, 1914–1929

Pig Iron	*1914*	*1929*	*Increase per cent*
Marked Price Cleveland Pig per ton	60/6	76/–	27
Rail Charges Actual	15/–	24/9	65
Rail Charges per cent	25	33	—
Steel Ship Plates	*1914*	*1929*	*Increase per cent*
Marked price per ton	£6 14 8	£8 2 8	21
Rail Charges actual	19/3	£1 11 11	65
Rail Charges per cent	14·3	19·6	—

It may be noted that railway rates were raised in 1920, just at the time when deflation was adopted, thus adding to the burden of the iron and steel industry at a time when Continental countries

were subventioning exports by charging only 50 per cent of the home rates as follows:

	100 *Miles by rail (steel per ton)*	
	Home	*Export*
Germany	11/-	6/6
France	10/6	5/-
Belgium	7/-	3/6

The Continental Steel Cartel in particular made considerable efforts to reduce freights on steel shipped to seaboard, and while British freight rates were decreased in 1928, as a result of the Derating Act, the cost of transport remained disproportionately heavy even on our home trade; e.g. the freight on finished steel in Luxembourg was about one-third the corresponding freight in Britain (4s. to 7s. per ton for 200 miles).

After 1921 iron and steel manufacturers pressed for 30-ton wagons for the economic marshalling of their traffic into trainloads and for a further improvement of port facilities for bulk loading and unloading.

Truck loading, which had been adopted for tinplates, could have been more widely applied. Tinplate rates in 1930 for 186 miles were

4-ton lots	29/6	6-ton lots	25/10	8-ton lots	24/3

An estimate of the transport costs on steel, subsequent to the assembly costs of materials for pig iron making, has been made for the five countries under comparison, as follows:

TABLE 78

ASSEMBLY COSTS IN 1927 (P. Tyler, *Iron Age*)

	Assembly Costs per metric ton Pig Iron	*Freight Allowance for Making into Steel*	*Inland Freight to Port*	*Total cost f.o.b. Port*
U.S.A.— Pittsburgh	30/5	7/6	21/-	59/-
Germany—Iron from Swedish Ore	10/10	2/6	3/1	16/6
France— Lorraine	15/5	6/3	8/4	30/-
Belgium	16/8	4/5	5/3	26/3
Britain—Iron made from Imported Ore	16/8	4/-	1/-	21/8
Britain—Home Ore	8/4	2/9	10/-	31/1

NOTE.—For the conversion of iron into steel an allowance of 20 per cent of the assembly cost was made and the freight on about 500 lb. more coal added. (This is excessive for billets, but not enough for sheets.)

The last item in this table deserves attention in view of the light freight charge to port imposed on steel made from British ores. It will also be noted that the U.S.A. was handicapped in export in spite of technical efficiency in long hauls, the average inland freight being about 12s. 6d. per ton higher than in Europe.

Some comparative railway rates for 1927–28 are given below:

TABLE 79

RAILWAY RATES PER TON-MILE

Goods	*Country*	*Average rate per ton-mile*
1. Heavy finished iron and steel	U.S.A.	0·45d.
	British	0·94d.
	German	0·85d. with 37% rebate for export and machinery.
2. Billets, Blooms, etc.	U.S.A. (Pittsburgh N.Y.)	0·43d. (0·21 for export)
	British	0·78d.
	German	0·56d. with 57% rebate for exports and machinery
3. Joists	British (50 to 25 miles)	1·5 to 1·0d.
	German	0·9 to 0·745d.

The Balfour Committee reported that the existing railway charges were seriously affecting our competitive position in the markets of the world. For every ton of finished steel, 5 to 7 tons of material were carried by rail so that at 3s. per ton moved, about £1 was added to the cost of finished steel. The Committee also estimated that 10s. was added per ton for delivery excluding dock charges. Another estimate of transport charges on finished steel at the time* was £2 per ton. It is known, of course, that some rebates were granted by railway companies, e.g. 10 per cent on ore and limestone as a whole—not regionally or by individual railways.

It will be observed from the above that the high cost of railway transport was a burdensome factor in the development of the British iron and steel industry, although this was favourably situated for export and import. Lincolnshire was more favourably situated than Lorraine or Luxembourg and the north-east coast had many advantages. British works near seaboard were not, however, able to reap the full benefit. Transport facilities were antiquated and organized on inefficient lines; subsidiary costs, such as handling and loading charges, were high and could not have been reduced by greater mechanization and concentration of traffic.

* E. R. Roberts, Buenos Ayres Great Southern Railway.

It may be said that this drag on the competitive power of the industry was a factor outside its control, but the lack of organization of the industry prevented it dealing with the Government and enforcing a co-operation of traffic services, inter-regional organization and the enforcement of traffic improvements.

Shipping Rates and Through Rates

Not only was Britain handicapped by high railway rates, but port duties and the rulings of shipping rings were adverse to the industry compared with other large steel-producing countries.

In 1894 the P. & O. line was charging 15s. 9d. per ton from London or Liverpool to Bombay or Calcutta and 10s. per ton for the same goods from Antwerp to Bombay or Calcutta.

In 1904 the industry complained of the through rates policy of the principal shipping lines, pointing out how Germany and the U.S.A. secured the lowest possible freight rates, and that differences in freight charges alone were sufficient to determine the success of foreign competition. Jeans gave the following examples:

	U.K. to Capetown (6,181 *miles*)	*U.S.A. to Capetown* (6,800 miles)
Galvanized Iron	20/–	15/–
Bar Iron	22/6	15/–
	U.K. to U.S.A	*U.S.A. to U.K.*
Bar Iron	22/6	15/–

Foreign transport companies were prepared to quote consolidated through shipping and rail charges on iron and steel products when in many cases British companies were not.

Examples of British lines discriminating against British manufacture could be multiplied, but the following will suffice:

(*a*) The L. and Y., G.C., and N.E. Railways charged 7/6 freight per ton from the East Coast to Antwerp and at the same time 3/6 from Antwerp to the East Coast.

(*b*) A New Zealand Shipping Company charged 35/– from Antwerp to New Zealand.

(*c*) The British India Line refused to send boats to Middlesbrough, but the Hansa Line sent their steamers as requested.

(*d*) British port to Mexico 17/6.
Antwerp to Mexico 5/– (German Line).

(*e*) Pig iron shipped to Antwerp was accepted at a 5/– freight rate on the same vessel which calling to load at British port imposed a rate of 17/6 per ton.

(*f*) Sheets and Plates. Liverpool–Montreal 13/9
Antwerp–Montreal 12/6

(g) Bars. Liverpool–Montreal 12 6
Antwerp–Montreal 9 0

(h) Castings. Railways accepted lower rates on Continental goods imported on a through bill than on British goods over the same track for export.

(i) Steel. Lower rates accepted for imported goods than on British manufacturers.

This acceptance by shipping lines of lower freights on goods imported into Britain than exported British goods of the same kind, and the acceptance by railways of lower rates on imported goods moving on British railways, whatever the reasons, had an obvious effect on British industry.

(j) Conclusions

It has been noted above, that the steel industry in Britain developed on different lines from those on the Continent. Apart from the lower cost of Thomas steel as compared with open-hearth steel, improvements in technology abroad established that basic Bessemer steel had more uses—was, for example, more suitable for tubes, sheets and wire. A greater number of trained personnel was employed abroad to work out the problems of the industry, and laboratory tests were mechanized and standardized at an earlier date so that foreign steel was more uniform in its properties.

After 1900 costs of production on the Continent fell below ours, and it became more economic for Britain to import semi-products and heavy rolled products. We failed to meet the competition in the early and intermediate stages of steel production, and only in those finished products in which we specialized did British exports continually increase. The tendency for Britain to export steel of high rather than low value was, apart from the point of view of national security, all to the good, and it was not necessarily a bad economic feature that our net exports fell from 1907 onwards. Apart from the tendency in all countries, however, for materials to be worked up at the source, others wished to partake in the more highly finished trade and this trend was particularly marked in the case of Germany and the U.S.A. Thus, combined with a relative failure in the early and intermediate stages of steel production, there was increasing competition in the later or finished stages, reflected in the changes which occurred in the destination of British exports. Before 1914 the European market occupied first place, but after the war the colonies and India became, due to preferential treatment, our best customers. The increase in British imports could not, of course, be entirely considered as a question of lower

foreign costs of production, as monopolistic discriminatory prices charged by protected foreign producers played an important role.

Britain did not fall behind so much in plant design and technical knowledges as in planning on a large scale, in integrated and balanced plants, in mechanization and organization to give a high output in relation to the working force. Whilst there was a lag in the development of methods of production of our heavy steel products, some of our finishing mills were not inferior to foreign mills, as in highly finished steels this country continuously dominated world markets. The success of our tinplate and galvanized sheet trades, however, only served to emphasize the value of organization and concentration. On the other hand, it must be admitted that small plants continued to exist in both trades, but the skill of the workmen was of a higher order.

The weak link in the chain of production occurred in crude steel and semi-products, and it must be associated in some measure with a lag in the adaptation of our early established works to mass production methods and the lack of the overall economy of balanced continuous operations. The early success of the British industry was due to certain natural advantages and inventiveness, but when low costs of production became the criterion we showed less resilience in adapting our plants and lay-out to large-scale production, and difficulty was experienced in renouncing traditional methods Except in highly finished steel, therefore, the higher British wage level resulted in high labour costs. The unbalanced construction during the war and the subsequent currency difficulties were a further disadvantage to this country, helping to impair the vitality of the heavy steel industry.

It does not serve much purpose to maintain that the plants in this country had to be resilient and adaptable in operation to meet the varied requirements of consumers if we were failing to compete as was the case. Our competitors chose to install highly mechanized plants and maintain them at full output, and were justified by the results. If the British steel industry had developed the output of plants by modernization, specialization, integration and concentration of output, with the attendant fuel and labour economies, its competitive strength would have been considerably enhanced. After 1920 it had to face exceptional economics and financial difficulties and it was too late to put its house in order unaided. The effort to modernize and reorganize should have been made much earlier in the century.

CHAPTER VII

Was there a Weak Factor in Organization?

(a) ORGANIZATION OF THE INDUSTRY

Organization of the British Industry

The next point to consider is whether the structure or organization of the British industry for production and distribution developed on lines which placed it at any disadvantage compared with competitive countries.

The procedure adopted is to outline the development of the organization in Britain and compare it with that abroad, as regards first production and then selling. Lateral and vertical association occurred simultaneously, but for ease of treatment the lateral movement towards association and cartelization is considered first, followed by the development of vertical integration or combination.

1. British Associations

The organization of the British iron and steel industry has never been easy to define. For a long time development was largely individualistic, with manufacturers competing for home and foreign markets. In spite, however, of the growing number of separate undertakings, competition was largely kept within bounds by the progressive increase in demand. Conditions were, however, favourable to restrictive agreements from an early date. District agreements existed in the wrought iron trade before Bessemer's invention. Between 1870 and 1913 several types of association were formed for price or output control in the steel industry but principally in finished products. The British railmakers had an association at the beginning of the period and a central selling agency was formed in 1880. In 1881 blast furnace owners had an agreement to restrict output and in 1882 steel makers agreed to "maintain prices." The weakness of the position was due to the multitude of producers, and their geographical dispersion and associations were, as a rule, transitory.

In 1898, however, the *Iron and Coal Trade Review* referred to the position as follows:

> "We have now in operation agreements or undertakings as to prices in the rail, ship-plate, boiler-plate, bar iron and other branches of the iron and steel trades of this country, by means of which prices are fairly well maintained and cutting is largely prevented."

Most of these arrangements, however, broke down, and the urge towards understandings and agreements was not strong until the turn of the century, when foreign competition increased.

Steel Makers' Associations were set up on the north-east coast in 1901 and in Scotland in 1903, and in 1904 they entered into an agreement as to the division of trade. A steel association was formed in South Wales in 1906 and later formed an agreement with the others which, however, broke down in 1912. Local and general agreements on ship and boiler plates were arrived at but broke down in 1913. The South Wales Steel Bar Association, which was formed in 1906, included in 1914 works with 95 per cent of the total output.

The Cast Iron Pipe Association was formed in 1908, and the National Light Casting Association, formed in 1911, included shortly afterwards about 95 per cent of the firms in the industry.

In the tinplate trade there was a pooling system and the National Galvanized Sheet Makers' Association functioned intermittently up to the War.

The agreements in the sheet industry were not only transitory but selling combinations were practically unknown. In products of which large quantities were imported, combinations were very limited or non-existent.

In spite of a greater propensity to price agreements after 1900, however, they were mainly considered as a temporary convenience. Dumping between districts was practised where there were no associations and Scotland, the north-east coast and the Midlands, with agreements on plates and sections, fought South Wales with a system of rebates.

In 1906 Jeans said that few products of the British steel industry were not regulated from the points of view of price or production. They must have been relatively ineffective for he also found that the ranges of price changes in this country were more serious than in other countries. He remarked, however, that German trusts "had probably not done us so much harm as is generally supposed."

During the war agreements increased and in 1917 thirty-six associations reported to a Departmental Committee of the Board of

Trade, and in 1919 there were forty associations in this country engaged in regulating prices and output (see Appendix vii).

In 1916 the report of the Committee referred to made the following suggestions:

(1) Reorganization of the industry and concentration in plants of over 300,000 tons capacity.
(2) Combinations should erect wholly new plants.
(3) Foreign mines should be bought.
(4) The formation of export selling associations.
(5) A temporary tariff
(6) Loans to groups of steel makers.

It was evident that no changes in structure were being made to meet new conditions and nothing except State action could bring about re-organization in a reasonable time.

Whilst there was a trend towards organization and methodical grouping, there was no effective national steel organization, though the National Federation of Iron and Steel Manufacturers, formed in 1918, constituted a unifying body to represent the interests of the whole of the industry. The Federation recommended collective ore buying, collective selling and the formation of international groups after the war.

Whilst many of the associations formed before or during the war ceased to function in the lean years that followed, a number were revived between 1920 and 1930, though mainly of a regional character. Ferro-alloys were controlled by rings, and the Wrought Iron Association was revived and had thirty-seven adherent firms in 1927. In 1923 the Steel Manufacturers' Association was formed by agreement between the midland makers and firms on the north-east coast and in Scotland, and fixed minimum home prices, but it was abandoned in 1925. The Light Castings Association broke down owing to the hostility of merchants.

The rebate system, which had been promoted by plate and section makers in 1910–11, was revived in 1927 with a view to promoting markets for British semi-finished steel. Rebates were also given by manufacturing associations to merchants selling only association goods.

An agreement was formed in 1922 in the tinplate industry to fix minimum prices, which embraced 97 per cent of the firms. In 1923 a selling syndicate was formed, and although the Tinplate Conference did not function continuously, a new pool was formed in

1929. The National Galvanized Sheet Makers' Association, revived in 1922, was joined by all producers.

The failure of association schemes in the 1920's was influenced by district jealousies and the desire for excessive compensation. Agreements only gained ground as an alternative to bankruptcy.

2. British Combinations

When the iron industry concentrated on the coalfields an increase in the scale of organization became necessary. Large blast furnaces do not use as much coke or as many men per ton as small furnaces, and similarly large mills possess technical economies. Technical integration is vital for low costs of production, particularly for the full exploitation of fuel economies. In the steel industry heavy capital costs and the desire to ensure the supply of raw materials also stimulate combination and amalgamations are better able to face the expense of new plant. Unfortunately, plants in Britain were not favourably situated for cost-reducing integration.

The development of combination and integration may, however, be traced as follows:

Up to the 1870's there was a rapidly growing number of separate undertakings in the British iron and steel industry, but there was also a growth in the normal size of industrial unit, and as it became larger there was a tendency towards the concentration of productive power in a smaller number of plants. Owing to the quasi *laisser-faire* development of the British iron and steel industry, however, the movement towards vertical integration, whilst clearly traceable, was slow in growth. A process of aggregation was, however, under way in Cleveland and Sheffield, under the influence of outstanding men like H. D. Pochin, Charles Markham, Tom Vickers, John Brown and Charles Cammell. A transfer of plants was occurring from up-country to the shores of tidal water. Before the end of the 19th century firms began to extend forwards and backwards to secure administrative and commercial economies. The establishments brought under common control were not, however, necessarily the most suitable.

In the decade prior to 1914 the tendency to combination was not marked. In 1903, in fact, pig iron firms were pig iron makers only, and even in 1909 steel firms were not engaged in pig iron making. Amalgamations were, however, being organized under the stimulus of growing foreign competition, e.g. Stewards and Lloyds (1902) and Baldwins (a combination of galvanized sheet makers).

During the war, while horizontal amalgamations were few, and while vertical integration was widespread, for example, the United Steel company (of which particulars are given below) and Colvilles, vertical integrations went into the highly finished trades and took over works in the Dominions.

The main post-war amalgamations were as follows:

In 1918 The United Steel Company Limited was formed by the amalgamation of nine firms owning ore mines, collieries, coke ovens, limestone and fluorspar quarries, iron and steel works. The constituent firms were:

Frodingham Iron and Steel Co.	Daniel Doncaster and Sons
Steel Peach and Tozer	Templeborough Steel Works
Samuel Fox	United Strip and Bar Mills
Workington Iron and Steel Co.	Appleby Steel Works and Plate Mills

In 1929 it became the Steel Industries of Great Britain Ltd., with a capital of £11,000,000, with the United Strip and Bar Mills included.

In 1920 Armstrong Whitworth Ltd. acquired the share capital of the Pearson and Knowles group and in 1927 combined with Vickers Ltd. to form the English Steel Corporation Group, having, with Cammell Laird Ltd., a capital of £8,000,000, which group John Brown and Thomas Firth were invited to join in 1929.

In 1928 the South Durham and Iron Company amalgamated with Cargo Fleet Limited with a capital of £1,250,000. Later, Consell and Pearce and Partners entered.

In 1929 Bolchow Vaughan & Co. and Dorman, Long Ltd. formed one of the largest steel concerns in the country, particulars of the capitalization being as follows:

	Bolchow Vaughan	*Dorman, Long*
Paid up Capital	£5,024,960	£8,018,056 } Total of fusion
Debentures	1,773,450	4,277,650 } £19,500,000
Control	Redpath Brown & Co. Darlington Rolling Mills Upton Colliery Co.	Bell Bros. Sir B. Samuelson & Co. Carlton Iron Co. North-Eastern Steel Co. Pearson & Dorman, Long Wade & Dorman, Ltd. (South Africa) British Structural Steel (Buenos Ayres)

In 1930 W. Beardmore Ltd. and David Colville Ltd., the two

largest producers in Scotland, combined with a capacity of 1,200,000 tons annually.

The Lancashire Steel Corporation (1930)—a product of "rationalization"—was an amalgamation of Partington Iron and Steel Company, Pearson & Knowles Ltd., Wigan Iron and Coal Co. Ltd. and Rylands Ltd.

In South Wales, Guest Keen and Nettlefold, Baldwins, Ebbw Vale and Richard Thomas amalgamated, having their own raw material sources and controlling 50 per cent of the tinplate trade.

The degree of fusion developed between pig iron and steel-making firms was partly due to the tendency of primary producers to enter the more profitable finishing trades. In 1927 there were 70 pig iron makers and 75 steel makers in Britain, but 30 companies controlled about 80 per cent of the output of iron and steel and 12 groups produced 47 per cent of the pig iron and 60 per cent of the steel. In 1928 pig iron makers owned 72 per cent of their ores and 62 per cent of their coal and coke requirements.

In 1930 70 per cent of British iron and steel was produced by 20 firms and 10 vertical groups possessed 47 per cent of the pig iron capacity and 60 per cent of the steel capacity of the country.

Combinations on the scale existing in the U.S.A. and Germany were impracticable as the total volume of production in this country was smaller and the industry was not so concentrated. No single district, for example, produced more than 30 per cent of the pig iron and 25 per cent of the steel, as contrasted with 75 to 80 per cent in the Ruhr. Integration proceeded a considerable way, however, and by the end of the period four geographical areas were partially dominated by a strong group.

3. British Sales Organization

The British iron and steel industry was founded and developed by relatively small concerns. The position of the merchant houses was a special one in that they were responsible for a large part of home and foreign sales, our export trade being largely built up by individual effort.

These merchant houses were at first in a sense common selling organizations, but later developed special connections with one or two manufacturers. In this way individual manufacturers built up a strong connection abroad but, as the period progressed, came increasingly in competition with organized export on the part of our competitors. The Continental producers and the U.S.A. being late-

comers relatively to this country in world markets, organized for aggression. Being better organized at home they attempted to correlate their distributing and marketing activities on a scale commensurate with production.

British overseas sales organization grew up fortuitously from the activities of large companies in particular markets and persisted long after it was evident that a sales organization could develop overseas markets better than any one company on its own behalf.

In 1894 the British Iron Trade Association investigated the question of the lack of vigour of our sales organization and came to the conclusion that merchant selling was not suitable to the new conditions. In the same year the German Iron Trade Association commenced its publicity to further the use of steel in building.

British industry was characterized by a superfluity of marketing units when a concentration of sales effort was required. British steel was sold by contact and reputation, but as consumers knew little about steel they did not know what to order except a trade name. Moreover, whilst some merchants were high-grade salesmen, as good as individual adventurers always have been, they were not technicians, and were to this extent at a disadvantage in comparison with the representatives of foreign sales organizations.

When the large concerns commenced direct selling, merchants dealt with the smaller firms or became disgruntled and took on the sales of foreign steel. Whilst merchanting may have been satisfactory in the early days of the industry when demand was elastic, as the steel age developed the problems of the industry ought to have been approached from the distributing end.

As Britain had no organized combination for selling, prices in world markets were governed by foreign exporters.

The wastefulness of competing firms covering the same field of distribution being apparent, sales organization arose after the war in 1914–18, in response to a demand for lower costs. The advantages envisaged in collective action in selling are in three possible directions.

(1) A higher price resulting from more scientific or more intense selling technique.
(2) Reduced selling costs from the elimination of individual efforts.
(3) Lower production costs from a larger volume of sales.

In the South Wales Tinplate Corporation the Richard Thomas group became the selling agent for a considerable section of the trade.

The British Steelwork Association was organized to promote the home market in constructional steel. It undertook propaganda market research and took orders for bridges and other work.

Except for the Tinplate Conference, which attempted a common selling agency, little was done in this country in the way of co-operative effort in export sales until the Steelmakers' Export Sales Committee was formed in 1928. It was superseded by the British Steel Export Association, which comprised all makers of plates and sections, i.e. shipbuilding and structural material. It took orders for and distributed the different sections thereof to the most suitably equipped manufacturers, special prices being quoted for big foreign contracts, which might take the form of rebates to British producers of finished products exported to markets where foreign competition was severe. British firms participated, however, in the international rail and tube cartels.

Organization of Foreign Industries

1. German Organization

Pig Iron.

Combinations in the German pig iron industry were under discussion from 1840 and first appeared as early as 1857, when the Verein zum Verkauf von Nassauschem Roheisen was formed. After the Franco-German War concentration occurred in the iron ore regions, the lead being taken by Rhenish Westphalia, where a scheme of price regulation was attempted in 1873.

In 1879 the Lorraine-Luxembourg Comptoir was founded and the Rhenish-Westphalian Roheisenverband was formed at Dusseldorf in 1886, with the object of fixing selling prices. The Rhenish-Westfalischewerkaufstelle was established in 1888 and a united sales office for the Rhenish-Westphalian and Lorraine-Luxembourg groups for the sale of phosphoric pig iron was set up in 1891.

In 1893 a sales office for foundry pig iron was established in Dusseldorf, and in 1894 the Verein für den Verkauf von Siegerlander Roheisen was formed and the Westphalian and Siegerland groups combined. The Sales Office first dealt with forge pig iron, then Thomas pig, and lastly foundry iron, but did not represent 100 per cent of the industry. Between 1894 and 1896 the three Sales Offices in Rhenish Westphalia were combined into one syndicate.

The Roheisen Syndicate zu Dusseldorf existed from 1897 to 1903,

being connected with the Lorraine-Luxembourg Comptoir in the Thomas Roheisen Sales Office at Dusseldorf. In 1897 and 1898 the competition from outside firms increased and the organization of the syndicate weakened. An Upper Silesian syndicate was established in 1901–2, and in 1903 the Pig Iron Syndicate at Dusseldorf was transformed into a limited company. The same year the Imperial Cartel enquiry was held, but the syndicate not only continued but extended its agreement with the Luxembourg group.

The Pig Iron Syndicate came to an end in 1908 after a life of twenty-one years, mainly owing to differences between pure and mixed works, but also to competition from outsiders. The success of the iron industry then sharply declined and attempts were made to reorganize the syndicate. In 1909 the price of German pig iron No. III stood at 53 to 56 marks per ton, compared with 69 marks before the dissolution of the syndicate.

In 1910 it was restarted as a limited company by the Rhenish Westphalian section, and by 1912 the last outsiders joined and the syndicate was complete. The Roheisenverband controlled about 97 per cent of the production of pig iron, grey iron, malleable iron and spiegel and supplementary combines completed its monopoly. It was one of the few cartels which persisted through the war in 1914–18, when army requirements took precedence over all others. The syndicate was prolonged till 1920, when during the post-war depression there was an enquiry by an Economy Committee, but it was, however, again prolonged till 1923.

In 1921–22 concentration of firms was exerting a profound influence on the quotas of production. During the Ruhr occupation in 1923 there were no supplies and at each renewal of the syndicate difficulties occurred due to quota distribution. The Roheisenverband withstood, however, the unfavourable post-war conditions while the German iron foundries were syndicated in the Verein Deutscher Eisengiesserei.

Steel.

Associations in the German steel industry are of ancient date. Tinplate combinations were formed in 1862 (the Koln Weiss). For the most part the associations were limited in extent except with regard to rails, girders, axles and fishplates, but in 1886 the combination of German rolling mills included the whole country.

In 1893 the Coal Syndicate was formed, and cartels for pig iron, semi-steel products, heavy sheets, rods, wire and nails. In 1900 the

Halbzeugverband was formed to include ingots, billets, slabs an girders, and the products were sold on behalf of its members. I 1904 the Stahlwerk Verband was organized and dealers forme themselves into unions. There were 28 firms in the Verband wit a joint selling agency. In 1905 there were 62 cartels in the Germa iron and steel industry, but they were continually grouping or re grouping.

In 1906 Jeans enumerated 46 different syndicates in the Germa iron and coal trades. The steel syndicates included semi-finishe steel, merchant iron, steel forgings, steel castings, rails, plates, sheets girders, pipes, tubes and wire.

The Stahlwerksverband then comprised all but 10 per cent o the steel manufacturing plants of Germany, employing 110,00 workmen and producing 7 million tons of steel annually.

At this time the opposition between pure and mixed works wa already marked, as the latter, making their own steel, were inde pendent of the Verband prices. A difference must be noted betwee the German combinations made by contract and the America form of a single large corporation, but the control exerted wa equally effective.

The Stahlwerksverband was renewed in 1908 and 1912 when i comprised 31 companies, including all Thomas steel works and a number of open-hearth steel works, and within the Verband itsel there was a tendency to concentration and integration.

Its aim was to combine control of all products of steel works and rolling mills, and it was successful as regards semi-finished steel, railway and structural steel. It became virtually a selling organization and a clearing house for orders, and its products were divided into two classes:

A. Products, consisting of ingots, slabs, blooms, billets, rails, ties, fishplates, etc. with structural steel in which it possessed a monopoly, selling for general account, and having a central technical bureau.

B. Products, consisting of rods, bands, hoops wire, sheet, tinplates, axles, forgings, rollers, etc. These were not sold by the Verband and there might be independent price cartels.

In the control of the Verband one vote was obtained for 10,000 tons of production. As the result of unified representation abroad, reductions in selling prices were effected. Bounties were granted on the export of B products made from A products in Germany, but the bounties were granted only to members of a cartel. Bounty adjustments were made at a clearing house in Dusseldorf.

Rebates extended throughout the German cartel system. The Coal Syndicate gave a rebate on coke if the iron was for export, the pig iron makers gave a rebate if the half-finished goods were for export. The wire rolling mills received rebates and in turn gave rebates to the Wire Tack Syndicate. The complications of the system led to the establishment in 1912 of a clearing house for export duties. Compensation was paid to syndicate members who were forced to accept unremunerative prices abroad. About 1906 the Wire Rod Syndicate sold in the home market at £12 per ton and exported at £7 per ton.

Before 1914 Germany had become noted for the concentration of its industry. Around the chief associations, the Westfalische Kohlensyndicat, the Roheisenverband and the Stahlwerksverband, were grouped other rings, syndicates and cartels. The Stahlwerksverband was the dominating force over all, but the firms were bound only by contract and might secede. Actually the renewals of the latter mentioned above were only made with some difficulty and it lapsed in 1919.

In 1908 the Schiffsbaustahlkontor (Shipbuilding Steel Office) was founded. The orders received at the central office were distributed to the most favourably situated works.

The Stabeisenverband (Bar Iron Union), founded in 1893, soon broke up. In 1909 practically all the steel bar producers united but their association failed to survive. In 1913 it was again formed but again failed.

In 1916 the domestic iron and steel was marketed through five dealers' associations. For foreign markets the syndicate fixed the export quotas of members and maintained a firm price policy lower than the domestic. The advantages claimed for syndication were: (1) regulation of production to meet the demands of the market; (2) reduction of the cost of selling; (3) maintenance of the price, to give a reasonable profit.

The Weissblechkonter (Tinplate Office, Cologne) did not limit production but concentrated the selling so that orders were equitably distributed. Forty per cent of the tinplate consumed was, however, imported from England.

For several years after 1918 the industry was unorganized except for the Pig Iron Syndicate. In the Ruhr it came largely under the control of a small number of big groups and production was increased beyond the market capacity so that a price war ensued. Demand was only 60 to 70 per cent of capacity and competition

between leading firms produced an uneconomic situation. An understanding regarding market policies between the various concerns was essential, the imminent cessation of duty free imports being a factor in the situation.

In 1924 and 1925 there was a revival of horizontal combination mainly stimulated by the strong competition of France and Belgium in the world market. In 1924 the Rohstahlgemeinschaft was formed to restrict output, but the syndicate did not restrict prices nor was it a joint sales organization. Orders were, however, allocated to the most economically situated works. Fines were imposed for exceeding production quotas but quotas might be transferred. The objects of the Rohstahlgemeinschaft were stated as follows:

(1) The development of the steel industry by the concentration and confident collaboration of the interested economic force.
(2) The adaptation of the production of steel by the contracting parties to the existing needs.
(3) The realization of common economic aims internally and abroad.

Its organization consisted of: (1) the General Assembly; (2) the Commission; (3) the Administrative services.

Germany was again controlled by associations covering most of the staple products. B products were effectively syndicated for the first time, and within the framework of the R.S.G. there were syndicates for finished products. In 1926 the Raw Steel Syndicate controlled 65 to 70 per cent of the steel capacity.

In 1925 the following cartels were formed:

A Tube Cartel for drawn and welded tubes; the German Rolled Wire Union; the Wire Union, and the Rolling Stock Union.

The Stabeisenverband was reformed to complete control of the sale of semi-finished materials, bars, heavy plates, hoops and strips, and a Wire Rope Association was formed in Essen in 1926.

There were associations of makers of fittings, rivets, screws, galvanized sheets for home and export, axles, shovels, hooks, files and horse-shoes. The cold rolling works had their own association.

On September 22, 1927 the German Tube Makers' Association bought the only non-member in West Germany—the Rohrenwerk Luxemburger, Dusseldorf—and closed the works. This was expected to improve the export trade. Krupps, who were outside the Tube Cartel, made an agreement with it in 1929. The Steel Trade Extension Bureau was organized to introduce new lines of manufacture.

The German Hoop Makers' Syndicate instituted a rebate system patterned on the British system to steel users.

In June 1929 the light gauge sheet producers combined (Feinblechkontor, Cologne) and in March 1930 a syndicate of German thin sheet mills was formed. The German Steel Foundries Combination comprised 65 firms and three in the Saar. At the end of the period a summary of the German steel works organizations was as follows:

ASSOCIATION	REMARKS
Stahlwerks Verband Rohstahlgemeinschaft* (Raw Steel Union)	Controlled production only and allocated output quotas.
A-Produkte-Verband* (A-Products Union)	Controlled sales of semi-finished steel, structural steel and railroad track material. Fixed prices and allocated sales quotas.
Stabeisen-Verband (Bar Union)	Controlled sales of merchant bars. Fixed prices and allocated sales quotas.
Grobblech-Verband (Plate Union)	Controlled sales of plates. Fixed prices and allocated sales quotas.
Bandeisenvereingung (Hoop and Band Syndicate)	Controlled sales of hoops and bands. Fixed prices and allocated sales quota.
Roheisen-Verband (Pig Iron Association)	Controlled production and sales. Allocated quotas.
Walzdraht-Verband* (Wire Union)	Controlled sales of wire products. Fixed prices and allocated sales quotas.
Rohren-Verband* (Tube Union)	Controlled sales of forged tubes. Fixed prices and allocated quotas.

* These syndicates were affiliated to the International Syndicates.

Sales Associations.

For the furtherance of export trade an agreement was formed in 1925 between the steel-producing industry (Raw Steel Syndicate) and finishing industries (Arbeitagemeinschaft der Eisenarbeitenden Industrie). Raw material (semi-finished products and rolled steel) was placed at the disposal of the steel-finishing industries at the same price as that at which it was available in other countries; the world market prices were fixed by a committee at the prices

which the Raw Steel Association had quoted f.o.b. during the preceding four weeks. This system of export subsidy consisted of an allowance made on the next subsequent order, at first up to 10 per cent, but after November 1926 up to 30 per cent of the new material. The agreement extended to cold rolled strip and special regulations applied to the export subsidy on quality steels and boiler tubes. On the other hand, the Pig Iron Association granted rebates at 6 marks per ton and calculated them half-yearly.

The German iron and steel trade was also cartellized in the form of dealers' unions, the German wholesale steel trade being regionally organized. There were traders' associations in each of the four selling districts into which the country was divided and prices had a freight basis.

The Tube Association sold gas- and boiler-tubes only to the syndicated dealers who were guaranteed their districts but could not handle foreign materials. Dealers and consumers were classified for rebates according to turnover. There was an agreement on similar lines between the Fittings Union and the associated merchants. Trade in the products of the Stahlwerke Verband was also cartellized, the agreements containing the usual exclusive clause, i.e. the traders must deal only in the products of the Verband, which, however, sold rails direct to large consumers. The Traders' Association included those dealing in half-finished products, mine rails, shapes, rods, strip and thick sheets.

In Rhenish Westphalia there were unions of independent steel merchants and associations of dealers handling foreign products with agreements as to price.

The export business of the Vereinigte Stahlwerke was carried on by the Steel Union Export Company, whilst the firm of Otto Wolff Ltd. organized its sales of sheets and also its exports to Russia, Turkey and Rumania.

German Post-war Integration.

Another aspect of the post-war reconstruction was rationalization of production, mass output programmes, standardization, labour-saving machinery, concentration of production in the most efficient plants and the cutting down of overheads. In 1925, in order to achieve further price reductions than were possible from syndication, the principal groups in the Ruhr explored the possibilities of amalgamation. Krupps eventually stood out but agreement was reached between:

(1) The Rhein-Elbe Union (Gelsenkirchener B.A.G.),
(Boehmer A.G., Deutsch-Luxemburg G. & H.A.G.).
(2) Thyssen Group.
(3) Phoenix.
(4) Rheinische Stahlwerke A.G.

The culmination of the trustification movement was the formation in 1926 of the Vereinigte Stahlwerke A.G. with a capital of 800 million marks and 120 million marks of bonus shares. The V.S., with its centralized technical and selling organizations, was, however, best described as a steel works union rather than a steel trust. Its magnitude was best gauged from its quotas in the various German syndicates as follows:

	Per cent
Pig Iron Syndicate	43
Raw Steel Syndicate	41
A-Products Syndicate	40
Steel Bar Syndicate	34
Strip and Hoop Syndicate	48
Thick Sheet Syndicate	44
Rolled Wire Syndicate	30
Wire Syndicate	24

As an indication of its size, the company employed over 150,000 workmen and over 15,000 staff. It produced over 6 million tons of pig iron and 6·5 million tons of steel per annum.

The effect of scrapping inefficient plant and concentration of production in more efficient works is shown in the following table:

Date	*Pig Iron Production Tons*	*Blast Furnaces*	*Per Blast Furnace Tons*	*Men Employed*	*Output per Man per Day*
Sept. 1925	735,000	96	7,600	21,000	1·17
Aug. 1926	850,000	84	10,000	17,000	1·60

In the same interval the steel output per man rose from 1·25 to 1·95 tons daily.

In 1930 control passed to Flick and Thyssen. Other fusions and absorptions occurred and the V.S. gained control of the Silesian Steel Corporation.

2. French Organization

In France attempts to form regional and national groups were made from the beginning of the period under review. While association in every country followed lines in accordance with its own peculiar conditions, in France, where financial power was extremely

subdivided, it took the form of the Comptoir. One of the first was the Comptoir Metallurgique de Longwy, formed in 1876 to stimulate the sales of Minette pig iron, which served as a guide for the formation of others. The Comptoirs were formed as limited companies under a law of 1867 and had an entirely commercial capacity, selling the products of the associated manufacturers.

The objects of the comptoirs included the standardization or unification of types of product with a view to lowering prices and a suppression of unnecessary expenditure on transport by serving each client from the nearest works. The comptoirs claimed that they stabilized prices and assisted in producing continuity of employment. The life of a comptoir was renewed every three years, when the quantum allocated to each firm was revised. The commercial director had to sell all the quanta; if more production was wanted the director had to bring pressure to bear on the firms. The iron and steel works could increase their capacity and demand a larger quantum and the director endeavoured to increase consumption as a method of lowering prices. The French comptoir allowed more freedom and individuality than the American trust, in which all firms were dominated and then absorbed, or the German cartels, which allowed little liberty to their adherents.

For a product to be controlled by a comptoir it had to be simple and identical from works to works, so that customers should not have reason to show a preference for one or another make. Some comptoirs dealt exclusively with the internal market, such as the Comptoir de Longwy, Comptoir des Foutrelles and the Comptoir des Aciers Thomas, Comptoir des Fontes Hematites, Comptoir Siderurgique de France, Comptoir des Toles et Larges Plats. Others dealt exclusively with export, such as the Comptoir d'Exportation des Produits Metallurgiques, formed in 1904 for the export of rails, girders and angles. It may be noted that in the next six years the quantity of these products exported quintupled. It joined l'Entente Internationale in the same year, sharing with other countries different export markets. Its quota was at first 5 per cent, but was subsequently raised to 9 per cent.

Another export association was the Comptoir d'Exportation des Fontes de Meurthe-et-Moselle, which sold all the cast iron made by its adherents except that intended for transformation at their own works. The comptoirs sold at a lower price abroad than at home, though it was said to be done only when internal consumption fell in order to make production more regular, and because products

had to be offered in the world market at a competitive figure. It was admitted that sometimes exports were sold at cost. The comptoirs functioned outside the Comité des Forges, though the same persons might belong to both.

There was a Centre d'Information or propaganda association for increasing the uses of steel, called "L'Office Technique pour l'Utilisation de l'acier." Its work included documentation, researches, information to consumers and users, films, exchange of technical services (producers and consumers), efforts towards a more regular flow of products, greater production and better technical knowledge of users' requirements. It published a weekly called *Acier*.

Although after the war in 1914–18 there were comptoirs in most branches of the iron and steel industry for the centralization of sales and fixing of prices and a general tendency towards amalgamation, the individualistic French character continued to exert a restraining influence.

Le Comité des Forges de France was established in 1864. In 1868 firms producing over 20,000 tons of pig or 1,500 tons of wrought iron were admitted. From 1868 to 1880 there was no president but it was controlled by a commission. In 1887 it was reorganized under President Martelet and production quotas were proposed for each member.

The Comité des Forges became a professional syndicate, constituted under a law of 1884. Its members were all maîtres des forges or firms with ore mines, blast furnaces, steel works, works for transforming iron and steel, foundries, forging and stamping shops. The members formed Chambres Syndicales (syndicates) for detailed attention to certain products. Thus in 1899 syndicates were formed for railway and tramway materials, also for naval construction and equipment, and in 1905 for war materials.

In 1905 the Comité des Forges was grouped with the three Comptoirs Syndicales de Construction Mechaniques and had the same general secretary. They were joined by the Comptoir Syndicales des Forces Hydrauliques. In 1923 there were 55 Comptoirs Syndicales included in the Union. The Comité was thus in relationship with the Union des Industries Metallurgiques et Minieres de la Construction Mechanique, Electrique et Metallique, of which the objects were to study all social, labour and fiscal questions of the industries represented by the component Chambres Syndicales, and to determine the line of conduct which they should all follow.

The Comité des Forges was concerned with all corporate interests

of its members and with developing the industry both in internal and external markets. It was not responsible for the acts of its individual members. According to the Year Book of the Comité, its object was the study and defence of the economic, industrial and commercial interests of the iron and steel industry. M. Pinot, the ex-Secrétaire-Générale, said, however, that ordinarily the Comité had no legal capacity to deal with commercial questions. It dealt with the inspection of steel and technical matters, as well as social and labour questions. The contributions of its members to the funds of the Comité were based on either production or the number of workmen employed if the firms were not producers of iron and steel. Regional committees were established, e.g. Comité de la Loire, du Nord, de l'Est, de Lorraine, de Champagne. The firms were divided into nineteen classes, according to the nature of the product manufactured. In 1923 there were 238 constituent firms of the Comité.

From the end of last century there was a more marked tendency to vertical integration in France, the impulse coming from the finished steel industries. It proceeded faster after the war in 1914–18 and the policy of the Comité des Forges, which was first a loose federation of the iron and steel industries, became largely dictated by five large trusts—Schneider et Cie, Wendel et Cie, La Marine-Homecourt, Les Forges de Denain-Anzer and Les Forges de Chatillon-Commentry. Large French firms also extended their connection to or obtained control of works in foreign countries, as exemplified by l'Union European.

3. Belgian Organization

The first permanent association in Belgium was the Syndicat Belge des Rails pour Chemin de Fer, formed in 1880, which combined all the steel makers. The following combinations were also formed: Le Syndicat Belge des Accessories de Rail (sleepers, fishplates, etc.) and Le Syndicat Belge des Rails à Gorge.

In 1904 the formation of the Stahlwerksverband in Germany led to consideration of the possibility of forming a steel syndicate. An invitation to a conference was issued by the Ougree-Marihaye Company and the scheme had the support of the Société-Générale Bank.

In 1905 the Comptoir des Acieries Belges was formed with which the syndicates mentioned above were fused. It constituted a central selling agency for the foreign and domestic sales of girders and steel rails, uniting eight manufacturers at first for two years. In 1907 it

was joined by manufacturers of semi-finished products, ingots and blooms. In 1911 all the Belgian works making these forms of steel were included, the Comptoir having absolute control of domestic and foreign sales.

L'Union Professionelle des Merchands de Poutrelles de Belgique was also formed, which purchased only from the Comptoir. Associations for tyres, axles, sheets and slabs existed for various periods.

The Belgian industry was not as compactly organized as the cartels of Germany owing to the difficulty of getting the smaller works to act in unison, but the comptoirs exerted a vigorous influence on foreign sales. A list of the principal works affiliated to comptoirs is given in the Appendix.

The products, the sales of which were controlled by the Comptoir were ingots, billets, blooms, sheets, bars, channels and joists, but not angles, plates or bars.

In 1927 the following associations or cartels existed in the iron and steel trade.

Product	Scope
Bolts and Nuts	Belgium
Machinery	Belgium
Wire	Belgium and Germany
	France and Luxembourg
Pig Iron	France and Belgium
	Luxembourg
Tubes	International

The Bank—La Société Générale de Belgique—played a preponderating role in the development of the coal-mining and iron and steel industries. It controlled Athus-Angleur et Moselle Chatelincau and had holdings in Cockerill, Ougree Marihaye and Burbach-Eich-Dudelange.

Le Comptoir des Acieries Belges represented Belgium with regard to the quota of crude steel manufactured by that country as an adherent to l'Entente Internationale de l'Acier.

The Syndicat Générale des Fondeurs de Belgique comprised 90 Belgian foundries. Its aims were:

(1) Economic studies relating to the industry;
(2) Improvements in the technique of production;
(3) Development of standardization and selling methods;
(4) Setting up of general research bodies

La Société Nationale des Chemins de fer Belges had a favourable tariff of freights on metallurgical products for export.

4. Organization in the U.S.A.

First Period of Concentration.

The U.S.A. is characterized by its self-sufficiency in natural resources, and from the beginning of the period under review combinations took a vertical rather than a horizontal direction. Price agreements and syndicates existed but they were local and gave way to consolidations and mergers. The organization of the United States Steel Corporation in 1901, constituting about two-thirds of the total capacity of the country, was the culminating point of the first period of concentration. Its development may be briefly outlined as follows:

In 1892 the Carnegie Steel Company was founded, combining the Carnegie and Frick interests. This, with the Federal Steel Company, itself an amalgamation in 1898 of seven companies, including the Illinois Steel Company, the Lorraine Steel Company and the Minnesota Iron Company, formed the nucleus of the U.S.S.C.

Other groupings absorbed were:

The American Steel and Wire Co., embracing most of the wire mills in the country.
The National Tube Co.—combining 13 concerns.
The Reid-Moore Group, comprising:
  The American Tinplate Co. with 39 plants and 279 mills.
  The American Sheet Steel Co. with 164 mills.
  The American Steel Hoop Co., combining 9 concerns.
  The National Steel Co.
The American Bridge Co.
The Lake Superior Consolidated Iron Mines.

In 1901 the U.S.S.C., organized from these ten companies, constituted about two-thirds of the country's possible output. The Corporation controlled 78 blast furnaces with an output of 7,400,000 tons of pig iron and 149 steel works with an output of 9,400,000 tons of crude steel and 7,700,000 tons of finished steel. In addition to the ore fields, it owned 500,000 acres of coking coal lands, 1,000 miles of railway, 112 vessels on the Great Lakes, with docks and limestone mines. Nevertheless, it had to purchase pig iron in the open market.

The initial capital of the Corporation was \$1,100 million (£220 million) with \$304 million (£60 million) bonds, but substantially half the Corporation's issue of securities was said not to be based on tangible assets.

The following additions were made:

1901. The Bessemer Steamship Co. and the Shelby Iron Co.
1902. The Troy Steel Products Co.
The Union Steel Co.
A merger of the Union Steel Co. having 5 blast furnaces and 24 open-hearth furnaces, with the Sharon Steel Co., owning various mills.
1904. The Clairton Steel Co. with 3 blast furnaces and 30 open-hearth furnaces and various mills.

In 1906 Jeans said the Corporation comprised 270 different iron and steel works, employed 160,000 workmen and had a capital of £300 million.

The production of the Corporation as a percentage of the whole country was: Lake Superior, ores 50 per cent, pig iron 45 per cent, rolled products 50 to 60 per cent, Bessemer steel 74 per cent, steel rails 65 per cent, structural shapes 58 per cent, wire rods 71 per cent, wire nails 65 per cent, plates and sheets 60 per cent.

The price of steel declined after the formation of the U.S.S.C., the advantages claimed for consolidation being: economy of production in cutting down duplicate expenses, avoidance of cross freights, and avoidance of changing rolls in rolling mills.

The main purpose of the Corporation was to impose an effective control over conditions of production and movement of prices. By not raising prices in 1901, it booked orders for months ahead, but when the slump came and the Corporation refused to lower prices, business went to the independent firms. In comparison, the independent manufacturers made greater progress, their capitalization per unit of output being less.

In 1903 the U.S.S.C. stock subscription plan was started. The next year the new plant at Gary was started up and in 1906 the Universal Portland Cement Company was formed, and the Hill Lease taken up.

The output of the Corporation in that year was 11·26 million tons of pig iron and 13·5 million tons of steel. In 1911, the year of investigation by the U.S. Bureau, 54 per cent of pig iron, 45 per cent steel ingots, 54 per cent finished rolled products, 46 per cent wire nails, 22 per cent wire netting, 33 per cent structural steel of the country's total were made. In 1919 it included 144 works with 124 blast furnaces, and possessed properties worth \$2,200 million, with a stock capital of \$1,500 million.

The U.S.S.C. was purely a holding company, its various members having their own distinct corporate organizations. When considered

as a unit it showed a low cost of production per ton but a comparatively high investment. Its heavy capitalization was said, however, to be due to investments in reserves of ore and coal and to have proved a sound financial policy.

The Anti-Trust Law held good in U.S.A., except for exports, but in March 1920 the U.S. Supreme Court decision was handed down that the U.S.S.C. was not a combination in restraint of trade.

It controlled less than 50 per cent of the country's production and a monopolistic position has not been secured. It was exposed to competition from similar consolidations and the independent competitors had increased their output at a greater rate than the U.S.S.C.

In the U.S.A., as in England, there were still gentlemen's agreements, steel conferences and open price associations. In the National Association of Steel Metal Producers, 97 per cent of the sheet tonnage capacity was represented. After the rise of powerful concerns outside the U.S.S.C. the risk of unrestrained competition first led to formal pools, which were admittedly illegal, then to understandings, and finally to "Gary dinners" (1907–11), gatherings controlling some 90 per cent of the total output.

There had been an increasing tendency towards industrial mergers—a second period of concentration—exemplified by the combination of Middle-West steel plants. The reasons for the mergers had been: severe competition, low prices and small profits, a result of over-capacity, and abundant credit in the post-war period.

Great advances had been made in the art of quantity production, the output per man having increased from 1½ to 8 times as much over a period of 25 years. There had been, however, no corresponding increase in quantity consumption and profitable distribution had proved more necessary than profitable production, the savings resulting from plant modernization having soon melted under competition. The advantages claimed for the mergers were: avoidance of duplication of efforts, reduction of production costs and sales work, checking of needless competitive expansion, less handicap in scrapping obsolete and inefficient plants, and co-ordination and unification of physical plants and operations. The effects of the amalgamations had been to steady but not raise prices.

In the nine years 1919–28, the six largest companies in the U.S.A. did not contribute more than 25 per cent of the total new construction for steel making, yet they represented 85 per cent of the

total steel production. Their efforts were given to refinements and economies through the improvement of existing plant.

In January 1928 two firms possessed 53 to 55 per cent of the total steel capacity and five firms made two-thirds of the total iron and steel. Ten companies controlled 82 per cent of the total capacity, viz. 47·5 out of 58 million tons, as follows:

	Million tons 1928	1930
United States Steel Co.	23·0	24·5
Bethlehem Steel Co.	7·9	8·2
Youngstown—Inland	5·0	2·7 plus 1·8
Jones and Laughlin Steel Co.	3·0	3·3
Republic—Trumbull Steel Co.	1·9	4·9
American Rolling Mill Co.	1·75	1·56
Wheeling Steel Co.	1·3	1·5
Colorado Fuel and Iron Co.	1·1	1·2
Corripan McKinney Steel Co.	1·0	—

Product	*Estimated Capacity of all Producers Million tons*	*Estimated Capacity of 10 Leading Producers Million tons*	*Per cent*
Rails	4·53	3·67	81
Plates	6·87	5·12	74·5
Shapes	4·43	3·87	85·5
Bars, Hoops	18·00	9·15	51
Tubular Goods	5·50	3·64	66·2
Sheets and Tinplates	8·70	3·64	42
Wire Rods	4·49	2·88	64·2

Of the remaining 11 million tons capacity, thirteen firms ranged between 0·3 and 1·0 million tons. Smaller manufacturing units owned only 6 per cent of the country's capacity.

The development towards concentration continued to the end of the period but the relatively small company still played a conspicuous part in manufacturing and the moderate size plant remained the typical unit.

The United States was not a dominant factor at the end of the period in the sale of iron and steel in any foreign market of importance. Although producing 45 to 50 per cent of the world's output they only exported 2½ to 3 per cent of the production.

U.S. Exports	*Million tons*	*Value Millions*	*Average £ per ton*
1925	1·79	$222·7	25·8
1926	2·201	$253·1	23·9
1927	2·218	$235·1	22

In comparison Germany exported $3\frac{1}{2}$ million tons of steel products and France over 4 million tons in 1927.

The U.S.A. competed strongly, however, in South American and East Asian markets, and exported automobiles and machines to Europe. More than half their exports went to Canada owing to the favourable freights. Home consumption was beginning to fall off relatively, and the small proportion of exports was the principal cause of export organization in the United States. The Steel Export Association distributed business in a particular market among the various mills which it included.

5. International Cartels

Before the war in 1914–18 cartels were largely, though not entirely, confined to individual countries. Whilst Britain joined, in fact took a leading part in forming, the International Rail Syndicate in the eighties, it entered few of the others, yet in 1914 there were 26 international agreements in coal, iron and steel and other metals. In 1904 the International Rail Makers' Association was enlarged and stabilized, and export quotas pooled. After the European War the tendency to form international cartels was stimulated by the increasingly competitive conditions for a diminished world trade. International organizations were formed in pig iron and ferro-alloys, crude steel, semi-products, bars, heavy plates, hoops and tinplates. In 1926 there were more than twenty in the iron and steel producing industries. The largest and most important was undoubtedly the European Raw Steel Syndicate which this country did not join. The rail agreement was reconstituted under the form of the European Railmakers' Association. Great Britain did not, however, belong to the International Rolled Wire Cartel, but for a time it entered an understanding with regard to tubes and also wire netting. British tinplate makers entered an agreement with the U.S.A. manufacturers with regard to export quotas and one with Germany was proposed.

A brief description of the International Steel Cartel may be of interest, although Britain only contacted the sales comptoir. Between 1913 and 1925 the capacity of Germany, Luxembourg, France and Belgium increased as follows: pig iron 25 million tons to 34 million tons, steel 25 million tons to 32 million tons. The demand of impoverished markets would not absorb this production and agreements were necessary to check competition.

From 1925 German manufacturers had exercised control over

the domestic steel market, but the full benefit of control was impossible without some form of international agreement. Discussions took place between Western European countries and the International Steel Cartel Agreement was signed in 1926. The total quota for the first quarter—September to December 1926—was fixed at 29·287 million tons. The participation quotas were as follows:

	Per cent		
Germany	43·18	Per cent of steel capacity	78
France	31·18	Per cent of steel capacity	95
Belgium	11 56	Per cent of steel capacity	85
Luxembourg	8·30	Per cent of steel capacity	90
Saar	5·78	Per cent of steel capacity	83

Each country was to pay $1 per ton of output to the expenses pool. Penalties were $4 per ton on excess output and compensation $2 per ton up to a deficiency of 10 per cent, reducing 2 per cent each successive quarter. The Cartel passed through many vicissitudes and cannot be said to have succeeded in its primary object of controlling output, as each country regulated its production in accordance with prevailing market conditions.

Germany had accepted an inadequate quota relative to her productive capacity—less, perhaps, than 78 per cent, relative to 95 per cent or more for other signatories—and concessions were granted her in the way of reduced penalties on her excess output. The Cartel prevented, however, dumping on the part of France, Belgium and Luxembourg into Germany. The imports of semi and finished steel from France and Luxembourg were not to exceed 6·5 per cent of her total consumption. Moreover, in 1927–28 the industry was able to operate near capacity and reduce its production costs. The total quota of the Cartel was increased in 1929 to 32·287 million tons. No country gave notice of withdrawal in October 1929, but Germany demanded more equitable treatment. Her home and export quotas were retained at 72 and 28 per cent respectively. The export quota was 300,000 tons of finished goods and 360,000 tons of ingot steel. Steps were taken to transfer orders from works whose order books were too full, to those less favourably placed.

In 1927 Czechoslovakia, Austria and Hungary formed the Central European Group, but this was dissolved in 1928 as Skoda and Poldi refused to pay the International Steel Cartel fines.

One object of the European cartel was to bring the world market near to home prices, an international control of trade being con-

templated within a "United States of Europe." The original plan of controlling the production of raw steel and limiting the output proportionate to world consumption had, however, proved insufficient to maintain prices at a satisfactory level. It was desired to close the total European steel production and a world agreement between the Continent and America was suggested, with territorial sharing and respect of colonial markets. This would have meant the end of free competition in the world market and negotiations to this end were proceeding in March 1930.

An organization was formed to distribute export orders, which means the cartel was to be enabled to compete more successfully in export markets. International selling organizations were formed and prices fixed f.o.b. Antwerp for many products, four preliminary cartels being organized to control export sales for a six months' period beginning February 1, 1930. It was proposed to determine the tonnage for each of the five major products which each member country might sell in export trade and in her domestic market. The export quota might be increased 50 per cent of its unsold domestic tonnage.

The International Sales Comptoir for semi-finished steel involved almost a world control, and was to be followed by comptoirs to handle other lines, e.g. structural steels. Committees fixed minimum export prices for certain products, viz. beams, merchant bars, wire rods, plates and rails f.o.b. Antwerp, and fifteen British merchant firms had agreed to quote prices fixed by the Continental entente for structural steel, bars, hoops, bands and plates.

The series of sales cartels for fortifying the production entente comprised four groups:

(1) Germany and Saar.
(2) Belgium and Luxembourg.
(3) France.
(4) Czechoslovakia, Austria and Hungary.

Until the end of 1929 the steel exchanges of Charleroi, Brussels and London determined the prices of most steel products; subsequently the Central Control Office of the Continental Steel Cartel did this.

In 1928 all countries exceeded their quotas, and Germany in particular, in spite of the Ruhr lock-out, was dissatisfied with her quota in the third quarter, although the penalties for over-production for export had been reduced. With regard to the Ruhr lock-out, she

also asked for a greater indemnity on under-production than the usual 10 per cent.

The International Cartel was renewed in March 1929, the total production being increased by two millions. In spite of Germany's increased quota, she claimed that it was only 85 per cent of her capacity. Production for the third quarter was increased, but by November prices were falling and a reduction of 10 per cent was proposed in addition to a revision of quotas. Germany also suggested fixing international steel prices by sales cartels, but as a matter of fact a gentleman's agreement on export prices was entered into.

In 1930 the 10 per cent decrease in production was continued but charges of under-selling arose and France was exceeding her quota. An international comptoir for semi-products was discussed, which it was hoped would function by August, but export markets were depressed and concessions were being made to buyers, so that minimum prices were not being observed. The control of bar prices was the first to go, followed by that of plates and sheets.

Comptoirs for semi-products and shapes were established on August 1st, but by September prices were thrown open to competition and the control disappeared. The whole International Cartel was threatened, but the framework was preserved and its life was prolonged from month to month. France received the same benefit as Germany in having to pay only one dollar for excess export tonnage. The restriction of total production was 30 per cent below that of October 1929.

In 1931 the bare framework of the International Steel Cartel was all that remained of a complicated structure, with the exception of the International Cartels in rails and wire rods. It had broken down under the strain of the world depression.

6. Conclusions. Appraisal of the British Organization

(a) *Associations.*

The above analysis has shown that associations in Britain did not develop as highly or as fast as in competitive countries, and the questions arise of why not and of how this affected the results over the period.

Why were the efforts of British associations to control output and price on the whole informal, immature and short-lived? It is true that by 1900 the Clyde and north-east coast heavy steel industries

had local price conventions, but by this time Germany had already organized national cartels and central selling agencies, and in the U.S.A. they had informal but successful price-fixing.

At the beginning of the period the individualism of our producers was, on the whole, successful, but as last century progressed the load of individualistic tradition exerted a retarding influence on development. The difficulties of associating the multiplicity of firms were immense but, on the other hand, incompatibility to concerted action did not prevent them from combining in certain home markets in order to fight more fiercely in others. There was no effective desire for association and collective action until immediately before the war, when it was evident that in some products (chiefly semi-finished steel) some Continental countries were continuously underselling us, both in the home and export markets. After the war there was a more insistent demand for internal regulation and control of the industry, due to the contraction of markets, the erection of trade barriers by economic nationalism, the difficulties caused to producers by continuously falling prices, and a deflationary monetary policy.

The transitoriness of associations was largely due to Britain's open markets permitting price domination by the export prices of highly organized industries abroad. What was the use of associations, it was asked, when not even the home market was assured?

Apart from the question of the disintegrating effect of the discriminatory monopolistic prices of some Continental industries, British producers were not so well laid out to manufacture certain steel products; there was intense opposition between pure and mixed works, and the industry could get no breathing space in which to reorganize. Such effective associations as existed were only in highly finished branches.

The aim of associations is to secure better and steadier prices. As regards the steadying of prices, however, there were, on the whole, less violent fluctuations in Britain than abroad before the European War. Nor must it be assumed that the existence of associations is any proof of increased efficiency and economy. On the contrary, associations of producers may be mere restrictive rings and cartelization a device to keep up the price of the product to that which will pay the least efficient firm.

The chief advantages of association are to procure a single voice fully representative of the industry and to look after its interests as a whole by co-operative selling and, perhaps, buying, in transport

negotiations, and in co-operative research and handling and the financing of export transactions.

It was in these directions that the British industry most suffered from lack of associations. One of the chief reasons why the British industry did not join the International Raw Steel Cartel in 1926 was the lack of a national organization that could commit the industry. Had it been better organized it would also have been in a better position to obtain more favourable rates from railway, shipping and other transport concerns. National associations are more effective for organized offence abroad and foreign competition was undoubtedly strengthened by the high degree of organization on the Continent.

(*b*) *Combinations.*

The organization problem with which the British industry was faced as the period progressed had several aspects, viz. the means of developing co-operative effort, the concentration of production in the most efficient plants and the formation of vertically integrated enterprises for technological and commercial economies.

One of the factors inducing lag in the formation of associations in Britain was the fact that the industry consisted for so long of a congerie of small isolated enterprises. The small normal size of firms at each stage of production also rendered it difficult to find a nucleus of large-scale plants required for vertical integration. Moreover, strong horizontal associations may, in themselves, threaten the existence of "pure" works and encourage vertical organization, as in the case of the German coal and ore cartels.

Not only was the growth in size of firms in the British industry slower than abroad, but the new steel plants added were of small scale. This was the opposite of what should have happened, as, owing to the greater age of the industry, there was a more pressing need for new large-scale units of production and for concentration of ownership.

Integration developed more slowly, however, in Britain than abroad, either between mining and steel making or semi-finished and finished stages, or between finishers and consumers or producers and merchants. It is, perhaps, surprising that there was a lag in concentration of control in Britain, in view of the freedom from restrictions on the formation of trusts. The iron and steel industry was, however, a family business, and integration is more suitable for joint stock companies than for private businesses.

Relatively to Germany and U.S.A. there was a lag in the size of businesses, in horizontal amalgamation and in vertical integration. This was partly due to the relative ease with which raw materials could be controlled and monopolized in the former countries where conditions were more favourable to the genesis of large vertical combinations.

Neither the British coalfields nor ore-fields were geographically concentrated and there was no threat of monopolization of raw materials. The absence of concentrated mass demand for pig iron gave the small British blast furnaces an opportunity to work with reasonable efficiency, but there was a general tendency to concentrate production in the technically best furnaces near the coast and an impetus towards vertical combination in spite of the opposition of the "pure" steel works.

Similarly the diversified demand for rolled products gave the re-rollers a reasonably profitable working on short runs, but their prevalence constituted a noticeable break in integration. Apart from the fact that many were very small firms, the economics of steel working were violated in regard to fuel and transport costs. A number of firms were making small quantities of the same product, whereas the whole of the re-rollers could have been substituted by one or two large and efficient plants. In any case, the re-rollers ought to have co-operated to form a giant steel-making firm which could have supplied the large quantities of semi-finished steel they bought from abroad. This missed opportunity in integration would have been of value from the point of view of national security, as well as from purely economic considerations.

In Britain it was not till the years following the European War that the trend towards large producing concerns was marked and vertical combination became a definite feature. On the whole, however, post-war changes were not large. There was re-equipment and improvement but no scrapping of old plants and erection of new. Big firms failed to drive out the small concerns due to internal weakness, mal-location and the jealousies of the owners of inherited control.

Due to intense competition and lack of reserves, technical developments in certain sections of the industry were not kept abreast of and plant was allowed to become obsolete. There was no coherent action on the part of the banks and no common reconstruction policy. No one, in fact, was prepared to take the risk and responsibility of capital investment on an adequate scale.

The difficulties of introducing mass production technique in the right proportion are well known, but they were not insurmountable. Towards the end of the period, moreover, no steel works with a throughput of less than 300,000 tons per annum could be considered a normal unit unless in some special section of the industry, but the majority of British works were smaller than this. Whilst there was a trend towards regional integration there was no inter-regional balance and no area was self-sufficient. Some regions (e.g. the north-east coast) produced more steel than pig iron. Others (e.g. Northamptonshire, Lincolnshire and the north-west coast) produced more pig iron than steel, a position indicating unnecessary and uneconomic transport of pig iron. Vertical integration would have reduced or eliminated this.

Even the largest steel-producing areas (the north-east coast and South Wales) did not, by the end of the period, make more than two million tons per annum each. This could all have been made in four or five works in each area but was not.

It would also have been easier, had the bulk of production been due to large firms, to organize for concerted action in regard to foreign trade.

It is not suggested that concentration in large vertically integrated concerns will necessarily yield more economic production. The experience of the Vereinigte Stahlwerke and Vickers Ltd. showed the dangers of over-centralization and that it is possible for an industrial and commercial unit to exceed the optimum size. Medium-sized concerns have greater flexibility and a lower burden of standing charges. It is, however, contended that as mass demand rose it would have been better met by concentration in a small number of integrated concerns with the attendant advantages in transport, selling, advertising and development work, in spite of the administrative difficulties.

Expert foreign comment at this time is not without interest. American iron masters were consulted on the post-war depression in our iron and steel industry. Mr. Schwab, President of the Bethlehem Steel Company, put forward the following recommendations:

(1) Protect the industry from invasion by a substantial tariff.
(2) Pay greater attention to home demand.
(3) Organize the great diversity of iron and steel makers into a few large groups, reducing the costs of production by wise amalgamations.

German comment was that Mr. Schwab's rationalization proposals

marked the end of Britain's "splendid isolation," and that large new steel works would have to be erected. Mr. J. L. Repogle was chiefly concerned with the reform of British steel mills, which he considered to be obsolete, but he thought blast furnace operation the weakest link in the chain and also criticized the coke-oven equipment. His chief strictures were on the management, which he considered conservative and unaggressive, and he blamed their persistence in regarding obsolete plant as assets when in reality they were liabilities. Repogle proposed the construction of three-million ton ingot producing units on the English and Welsh seaboard, but the cost was excessive. At this date Professor Jevons estimated the cost of national reorganisation at £150,000,000.

In summary it may be said that throughout the period the structure of the British industry was characterized by relative stationariness. There was no technological boldness but a lack of courage in direction and an apparent desire to put off changes as long as possible. Additions, remodelling and patchwork reconstruction were preferred to a new start on a large and balanced scale, involving a redistribution of production centres from the districts becoming uneconomic to the areas where ores were cheapest. There was no apparent appreciation of which were the locations of low cost in production and assembly, and natural resources and facilities were not fully exploited.

Radical change in Britain should have come early in the period when the industry was seen to be suffering disadvantage from having pioneered in the wrought iron trade. Steel making was amazingly scattered in small-scale plants. Even in the nineties the common steel makers were not expanding, due, among other reasons, to obsolescent localities, and it required a Carnegie to deal with the situation. By the end of the century a large steel plant ought to have opened up the Midland ore centres, where it was recognized that cheap pig iron could be made. New plants in better locations were known to be required, but as it was nobody's interest to effect technical and locational integration of all stages (except, perhaps, the manufacturer of finished steel), growth was haphazard, sectional and unco-ordinated. The international creation of excess productive capacity rendered consolidation necessary, but the pace, scale and timing were wrong, and when rationalization was attempted it was too late to be of service to the British industry in the world depression.

(c) *Distribution.*

It has been noted above that there was relatively little co-ordination between the different stages of manufacture in Britain and less between distribution and production. The distributive system had been built up on the basis of merchant firms and up to the outbreak of the European War there had been no serious effort towards organized representation of sections of the industry in home or foreign markets. After the war the work of the British Steelwork Association and the Steel Export Association indicated what could be done on these lines, but only the first steps of concerted action in commercial distribution had been taken in this country. British firms had sometimes had tendering agreements in relation to foreign business, but distribution and marketing activities could only have been organized on a scale commensurate with production by common selling agencies such as had been adopted by Continental export cartels.

It is not contended that Continental syndicates for fixing prices and distribution markets had been an unqualified success. International cartels had only been successful in prosperous times; in times of crisis the foundations of the agreements were always threatened.

It is suggested, however, that an important cause of the extension of Continental export trade was due to the energy and enterprise of syndicates such as the Avi Abkommen, and that our industry suffered not only from their freedom to exploit the open British market, but also from the lack of counter-organization of British distributors.

(b) ORGANIZATION OF LABOUR

In this section the question is considered whether relative retrogression of the industry during the period may have been associated with any restriction imposed by the organization of British labour. The development of trade unions in the iron and steel industry is first outlined and consideration then given to hours of labour and wages in the countries under comparison. A short investigation is also made of the position and influence of technical workers.

1. The Development of Trade Unions and Joint Control

The trade union movement commenced in the British wrought iron industry in the sixties of last century, the Associated Iron and

Steel Workers of Great Britain being formed in 1862. Under the *laisser-faire* conditions in this country, the iron unions successfully adapted themselves to the new technique of steel making and. steel unions developed as early as 1871, when the Independent Association of Tinplate Makers was founded.

The principal unions formed in the eighties were the British Steel Smelters' Association (1886), the Amalgamated Steel and Iron Workers of Scotland (1888), and the National Steel Workers' Association (1888). Some of the unions were transitory, but by the end of the century the melters, millmen and sheet workers were organized in most parts of the country. Up to the outbreak of the War the period was characterized by the development and stabilization of unionism and consolidation may be said to date from 1914.

As a result of a conference in 1915, the Iron and Steel Trades Confederation came into being in 1917 from a fusion of the following unions:

The British Steel Smelters' Association.
The Associated Iron and Steel Workers of Great Britain.
The Amalgamated Steel and Iron Workers of Great Britain.
The National Steel Workers' Association and the Tin and Sheet Millmen's Union.

The Confederation was based on a scheme dividing the country into seven parts with Divisional Committees. The membership attained 50,000 but was far from including the whole of the workers. Unions included in the Federation were the National Union of Blast Furnacemen, the Amalgamated Wire Drawers' Society, and others representing workers within the steel industry. Some of the men belonged to unions whose principal membership lay outside the industry. In spite of the amalgamations that had occurred, the British industry was, at the end of the period, a good way from complete organization, but compared with other countries, except Germany, it was highly organized. The latter country had representative trade unions and there was, in fact, a general similarity with Great Britain. Whilst trade unionism and collective bargaining was well developed in these two countries, there was practically untrammelled control by the employers in the U.S.A., France and Belgium. In the American iron and steel industry trade unionism was quite ineffective and in many works contracts of service did not exist. In France there was no effective organization of workers for wage settlements or collective agreements. In Belgium the Metal

Workers' Trade Union had been organized but collective agreements were not binding and wage contracts were made between the employer and the individual workers.

Labour relations, hours and wages in the United Kingdom were generally regulated and controlled by agreement. The machinery for negotiation was obtained by the institution of Joint Conciliation and Arbitration Boards, comprising equal representation of employers and employed. The first joint board was organized in the wrought iron industry in 1869 and related to the Manufactured Iron and Steel Trade of the North of England. In 1872 a joint board was set up by the Iron Masters' Association and the Iron Workers' Association, which afterwards developed into the South Staffordshire Iron Workers' Board of Conciliation. In its permanent form it became the Midland Wages Board. Conciliation Boards in the tinplate trade dated from 1874. The joint board movement developed rapidly and between 1890 and 1892 sixteen local district conciliation boards were formed. In an address in 1899 Sir Robert Austen spoke of "the deplorable aspects presented by what is known as the labour question" and referred to "many strikes in the last few years." He hoped that the boards of arbitration and conciliation would have an immediate beneficial effect. On the whole, however, the method of wage negotiation involving joint boards, joint conferences and joint industrial councils met with a large measure of success. In all wage disputes the price obtained by the manufacturer had been the dominant factor in awarding advances or reductions. Automatic sliding scales were adopted as early as 1869, but it was not until 1889 that the Midland Iron Trade Scale was formed on a permanent basis. Towards the end of the period, 60 per cent of the workers were on a sliding scale wage system, revised periodically according to the selling price of iron and steel.

The system was effective in pig iron, wrought iron, heavy steel and the sheet and tinplate trades, but not in the Sheffield trades and some others. It may be said that the British form of industrial government worked successfully, with relative freedom from disputes in some very difficult years.

In Germany the similarity to Great Britain extended to wage settlements as well as organization. The conciliation and arbitration system was much the same in principle, policy and difficulties, and also gave reasonably successful results.

2. Effect on Hours of Labour and Employment

(a) *Hours of Labour.*

Whilst statistics on the number of workers and working hours in the iron and steel industry are incomplete and international comparisons difficult to make, particularly in the early part of the period, some information is, however, available (Table 131 in Appendix) and permits general conclusions to be drawn.

At the beginning of the period under review hours were mainly uncontrolled, with twelve-hour shifts common to all continuous processes. The movement towards an eight-hour shift was initiated in Britain, being adopted at West Hartlepool in 1897, in 1905 at Port Clarence and before 1914 at blast furnaces in Durham, Cleveland, the west coast and South Wales. The three-shift system had also been the practice for some time in the tinplate mills, and was later adopted in melting shops and rolling mills of the South Wales Siemens Steel Association. In 1906 the average hours worked in this country were 55·2—blast furnaces 55·2, steel works 54·4, and tinplate works 47·8 per week. In the Ruhr the average hours worked per week in 1913 were 54·6. In the U.S.A. in 1913 the average for the whole industry was 66·1 hours per week. Blast furnaces were largely on a twelve-hour basis and mills operated two turns per day of nine to twelve hours each. Though the evidence is sparse, there is an indication that before the war working hours were slightly shorter in this country than abroad.

After the war the position was as follows: the eight-hour day was first applied generally in 1919 in the British industry and in 1923–24 abroad. In Germany, however, the eight-hour day was extended at the end of 1923, and in 1924 an average of 57·5 hours per week was worked. The eight-hour day was again made compulsory in 1925 and hours fell to fifty-two per week in 1928. In France an eight-hour day was provided by law but extra hours up to one hundred per week might be, and were, worked if the Inspector of Labour was duly advised. In the U.S.A. there was little change in the hours of work after 1923–24—54 hours per week in 1929 as an average for the whole industry against 55·2 for 1924.

The comparisons on page 241 of British and Continental working hours per week were made in 1924 and 1930.

Except at blast furnaces, hours of labour in the steel industry were shorter in this country than on the Continent or in the U.S.A., where hours were longer in all branches of the industry (see Appen-

WORKING HOURS PER WEEK, 1924 AND 1930

		United Kingdom	Continent
1924	Blast Furnaces	56 hours	56 hours per week
	Steel Works	$42\frac{1}{2}$–$47\frac{3}{4}$ hours	52 hours per week
	Rolling Mills	42–45 hours	48 hours per week

		Britain	*Germany*	*France*	*Belgium*	*Luxembourg*
1930	Pig Iron	56	56	56	56	56
	Steel Melting and Rolling	47–45	52–48	50–48	52–48	50–48
	Wrought Iron	45–$42\frac{3}{4}$	$52\frac{5}{16}$–48	50–48	52–48	40–48
	South Wales Siemens Furnaces	44–42	52–48	50–48	52–48	50–48

dix), but before enquiring how far British labour was responsible for this a brief examination may be made of the effect of shorter hours.

When the change over to an eight-hour shift was made the effect on output and costs was disputed. At blast furnaces there was very little increase in output, but at steel-melting furnaces there was a definite increase, which has been estimated to average 15 per cent. The output of rolling mills and forges was increased, but on the other hand the output of some processes, e.g. of woven wire, was reduced. The effect of a reduction of hours depends, of course, on the circumstances, the degree of continuity of the process, the extent to which the rate of output is decided by the plant and not the men, the liability to fatigue and so on, but evidence shows that the reduction of hours in most cases increased the output so that the mere fact of a reduction of working shifts is not necessarily restrictive. In the U.S.A., for example, after 1924 it was found that the works and mills could bear the higher payroll resulting from the shorter hours owing to the increased productivity of the plant. Productivity in the iron and steel industry was mainly and increasingly influenced by the degree of mechanization and the efficiency of organization, which are out of the workers' control. The skill of workers became of decreasing importance and developments threw more and more responsibility on semi-skilled men capable of minding a piece of plant. Commercial success was no longer dependent on the dexterity and ability of the workmen, but chiefly on the lay-out and working of the plant. Much play was made in this country on the subject of hereditary metallurgical skill, but it was shown during the war in 1914–18 that it only took six months to

train a melter on an open-hearth furnace. As mechanization and automatic control in metallurgical works progressed, the personal

prior to 1914, but during the war 300,000 persons were drawn into the iron and steel and engineering trades. From 1921 onwards depression caused continual contraction in the number of workmen. The percentage of unemployed was amongst the highest in the insured trades, and during the last seven years of the period it stood near 20 per cent except in 1926 and 1930, when it was higher still.

It will be seen that, apart from the year of the coal shortage, there was less unemployment in pig iron making than steel melting and rolling.

(ii) *Germany.*

Unemployment varied monthly as follows:

1923	12 to 51 per cent
1924	9·3 to 27·5 per cent
1929	14·1 per cent

but was not, on the whole, as high as in Britain.

(iii) *France.*

There was little unemployment in post-war times. Two hundred thousand foreign workers were employed in iron and steel works and iron ore mines.

(iv) *Belgium.*

Employment was characterized as good in post-war years. In 1930 no unemployment was recorded.

	Employment Index	*Average of 32 Plants*	*Plants with Employment Stability 95 %*
1921	68	—	—
1922	77	—	—
1923	97·5	88·9	6·7 %
1924	87	88·3	12·5 %
1925	88	91·2	28·1 %
1926	92·5	94·3	46·9 %
1927	—	93·6	31·2 %
1928	—	94·2	53·2 %

3. Effect on Wages

The wages paid in iron and steel works have been examined above and it was shown that the level of wages increased in all countries during the period reviewed, and that the money wage level remained consistently in the following order:

(1) U.S.A., (2) Britain, (3) Germany, (4) France and Belgium.

Real wages were probably in the same order, but certainly not in the same proportion. The cost of living was much higher in the U.S.A. than here and lower on the Continent, where the effect of the works being located in agricultural districts tended to compensate the lower monetary wage.

As regards the money wage level, the highest and the lowest wages were paid in countries where the labour organization was ineffective and collective agreements inoperative. In Europe, however, the highest wages were paid in those countries—Great Britain and Germany—where the trade union organization was most highly developed, and this held good throughout the whole period. At the beginning of the period, when Britain was predominant in iron and steel production, trade unions and wages boards were already in existence. Before the European War, when Germany gained the premier position in the European iron and steel industry, her trade unions there were highly developed. The mere existence of highly developed labour organizations was not, therefore, a restriction or inimical to a powerful and prosperous iron and steel industry. Trade unions are, however, more effective in retarding a fall in wages than in gaining a rise; after 1920, in particular, the unions maintained wages when they might have fallen in this country and Germany, and undoubtedly wages were disproportionately high in this country in relation to the output of the workers. High wages could only be paid if the labour cost was no higher than in low wage countries. Labour could, therefore, only be held responsible for any decline in British competitive efficiency over the period in so far as the trade unions maintained wage costs above economic limits. Generally speaking, wages in the iron and steel industry were not related to the output but to the prevailing price in the preceding period. The British employers claimed, however, that the standard wages were fixed too high and were out of proportion to the services rendered, which indicated an acceptance of the principle that wages should be related to the gross productivity.

After the War German employers also complained that the level of wages was too rigid, due to compulsory arbitration. A principle of equity was involved in relating wages to the output of a given plant, but output was principally dependent on mechanization of production and transport and on industrial organization so that while labour may have prevented the fall of wages as quickly as the economic position demanded, the maintenance or raising of wages depended chiefly on the actions of the management in

improving the efficiency of plant and equipment, either by scientific or by economic inventions. Something was undoubtedly wrong with British wages, not in their absolute level—because the American industry could afford to pay nearly twice as much—but in the proportion they bore to total costs.

The wage level in Britain was not in itself an important factor in the difficulties of the iron and steel industries. At the beginning of the period wages were higher here than abroad except in the case of new countries like the U.S.A. and Australia, but this country possessed superior equipment, technical knowledge and experience. During the sixty years under review the efficiency of production in the lower wage countries drew level and in some instances surpassed that in this country. While, therefore, wages could not, in the long run, be maintained above a level rendering labour cost higher than that in other countries, the difficulties could not have been solved by changes in wage rates alone. Wage reduction would, in general, only have resulted in an insignificant reduction in selling price. Organized labour might, therefore, have been responsible for imparting a lack of resilience in British wages, but a more important factor in the change of position since the beginning of the period was the productivity of the plant which had not, in view of the development of mass consumption, been maintained in a position of relative superiority.

Conclusions

To show that the relatively unsatisfactory economic development of the British iron and steel industry outlined in the opening chapters was associated with the role played by labour, we should have to establish that organized labour had unduly shortened hours or prevented their rise, or had unduly raised wages or prevented their fall in the face of falling prices, or had acted in some other restrictive way so as adversely to affect the amount of trade obtainable by this country.

It is, however, suggested that, although the labour unions may have been instrumental in the somewhat shorter weekly hours than in other countries, this could only have had a restrictive influence on output in a few processes.

Labour relations throughout the period were on the whole good. There was no major dispute over half a century, and it is unlikely in these circumstances that the working of the industry could have suffered serious interference from labour rules, customs or policy.

It has been indicated that unions are more effective in maintaining wages than in raising them, but that it is pointless to discuss wages and earnings without reference to productivity. As British unions were well established at the opening of the steel era, they may have been partly instrumental in the establishment of a higher wage level than on the Continent at the beginning of the period, but at that time the relative productivity was such that the industry could stand it. If the industry subsequently lost in relative advantages in gross productivity, this was entirely out of the control of organized labour.

After 1920 the labour unions maintained higher wages than the productivity of the industry could afford, and this may have been a serious factor in the post-war industrial crisis. It is difficult, however, to see what could have been done about it, as even a drastic reduction in the standard of living would not have brought British total costs down to those of the Continental industries, especially as it was obvious that a fundamental re-organization of the industry was required. Whilst, therefore, labour unions may have at times exerted a restrictive effect on the expansion of the industry, it is contended that it was not the major influence in the relative deterioration.

(*c*) ORGANIZATION OF TECHNICAL AND MANAGERIAL STAFF

Practically all the fundamental inventions in the steel industry originated in Great Britain, but in the last fifty years of the period under review there appeared to be a slackening in leadership and pioneering work. The first statement is undisputed even by foreign metallurgists, but the second also appears sustainable. Britain did not retain the initiative after the fundamental inventions. The industry was slowly penetrated by science and failed to appreciate that it was entering a new highly technical phase; in fact, till the end of the period, it maintained an alchemistic secrecy in regard to its processes.

The contributions of foreign metallurgists in the pig iron industry have been noted above in the development of larger furnaces and more efficient handling equipment, in gas-cleaning and utilization, in the economic use of the gas engine, and so on. They also progressed in the construction of large steel furnaces, the development of high speed mills, the use of automatic and electrically heated furnaces for steel treatment, in the mechanization of steel foundries and in other ways.

After the war in 1914–18 it cannot be said that this country led

the way in inventions connected with iron and steel. For example, in the development of electric furnaces, in the introduction of new metals such as high nickel-chromium steels, steels capable of being surface hardened by nitrogen, and in new cutting alloys, the contributions by foreign metallurgists were at least as noteworthy as those of this country. Metallurgists abroad were just as studious, as keen and inventive as our own, and technical knowledge evened up rapidly all over the world. They had, in some cases, greater facilities in research; there was, for example, no counterpart here of the Kaiser Wilhelm Institut, or of some of the larger American laboratories.

The organization of co-operative research work in this country did not, by the end of the period, compare favourably with that in Germany and the U.S.A. In the former country co-operative research associations started with the founding of the Verein Deutscher Eisenhutten leute in 1860, the work being carried out by a number of committees. For the solution of fundamental problems the Kaiser Wilhelm Institut was established in 1918. In the U.S.A. a Metallurgy Advisory Board was organized in 1923, consisting of members of the industry, the Bureau of Mines and the Carnegie Institute, and in 1926 the Board launched a five-year programme of research.

In this country the Department of Scientific and Industrial Research, which was set up in 1916, fostered industrial research of many kinds, but the Industrial Research Council* of the National Federation of Iron and Steel Manufacturers (referred to later) was not established till 1929, with the object of organizing and applying technical advances so as to raise the general level of the industry.

The importance of rapid application on a commercially economic scale of technical advances was earlier appreciated abroad, but, on the other hand, the economic need for intensive application was greater abroad, as the only means of countervailing our earlier start in steel production.

* The Iron and Steel Research Council made important contributions towards increased productive efficiency. The Fuel Economy Committee was responsible for an appreciable reduction in the coke consumption per ton of pig iron in spite of an increased weight of burden. It was also instrumental in reducing the amount of coal used in iron and steel works per ton of finished steel.

A number of Research Committees were set to work on subjects of fundamental technical importance; the Blast Furnace Committee studying among other aspects of furnace work, reducibility of ores, coke research, blast furnace practice, air blast, instruments of control and costs; the Open Hearth Committee worked on furnace output per unit of hearth area, bath depth, heat input and regenerator efficiency. Other committees included the Steel Heterogeneity Committee, Corrosion Committee, Welsh Plate and Sheet Manufacturers' Committee, Research Committee, the South Wales Siemens Steel Association Research Committee and the Sheffield Smoke Abatement Committee.

Technical education for men entering the iron and steel industry was somewhat neglected in this country—while the training at Sheffield University later became an example to the world, it is doubtful if it was as intensive as in the Hochschule and Ecoles Supérieures on the Continent, or in post-war years in some American colleges. The question of the promotion of technically qualified men in the country is also a subject for criticism. Apart from the ultimate control of the industry having been in the past largely a family matter, employment on the technical side appeared to be a bad approach to the directorate.

A comparison of the number of technically qualified men employed in our iron and steel industry with that in German works, while in favour of the latter, was not so important a point as that the fuel experts, plant engineers and metallurgists should have occupied positions where their voices could be heard.

Organization of the iron and steel industry became a matter of increasing technical complexity, practically all the inorganic sciences being drawn on to make the processes of extraction, manufacture and treatment an economic success, but the British industry followed traditional paths in promotion to positions of control, though decisions became increasingly dependent on technical matters. It is not surprising, therefore, that there was a degree of failure to forecast technical change and development.

Management.

The ultimate control of the British iron and steel industry has been in the past largely a family matter, which, together with an unduly acute individualism, accounts for men without any special training attempting to manage large industrial concerns and for a loose works management.

The sense of security from inherited wealth explains an inherent conservatism, and a marked tendency to retain aged directors led to a love of compromise, a hesitant development of policy and opposition to change except when driven.

There can be no surprise, therefore, at the tendency noted above of a lack of appreciation of the severity of the problems to co-ordinate production and sales in developing mass demand. If inadequacy of training in regard to works management is charged against the developing British steel industry, there is small wonder that the training of foremen was deficient or non-existent, though a German scheme of training for foremen is recorded as early as 1880.

CHAPTER VIII

Profitability and Capitalization

Profits

It is extremely difficult to determine the profitability of the industry as published dividends do not indicate whether adequate allowances were being made for depreciation and plant replacement. There is a great paucity of data regarding the first part of the period, and the results of individual firms may or may not be characteristic of the profit-earning capacity of the industry at the time.

In 1904 Jeans divided British iron and steel firms into two categories: (1) those making high profits; (2) those making low or no profits. The firms in group (1) were found to possess one or more of the following advantages: the manufacture of specialities, the control of raw materials, low capitalization.

When the period opens the British industry was undoubtedly profitable, but during the seventies the dividends diminished and in the late nineties practically disappeared. The profitability of the industry has, in fact, always followed Carnegie's dictum that it was either prince or pauper.

From 1890 to 1900 there is evidence that good profits were being earned in the U.S.A. In 1899 profits made on pig iron in Pittsburgh were enormous, while big profits were also made in steel.

TABLE 81

PROFIT ON PIG IRON IN THE U.S.A., 1890–1900

Year	*Average Cost of Production*	*Selling Price*	*Mean*	*Margin of Profit*	*Mean*	*Per cent*
1890	62/0	66/6 to 94/6	80/6	4/6 to 32/6	18/6	23
1891	51/0	60/6 to 66/0	63/3	9/6 to 15/0	12/3	19·5
1892	53/0	55/6 to 62/6	58/9	2/6 to 9/6	6/0	10
1893	45/6	44/9 to 55/6	50/1	−0/9 to 10/0	4/7	9·0
1894	34/6	41/3 to 52/6	46/10	6/9 to 18/0	12/4	26
1895	38/0	40/0 to 68/6	54/3	2/0 to 30/6	16/3	30
1896	48/0	44/0 to 53/6	48/9	−4/0 to 5/6	0/9	1·5
1897	38/0	37/9 to 43/0	40/4	−0/3 to 5/0	2/4	6·0
1898	39/0	40/0 to 42/6	41/3	1/0 to 3/6	2/3	5·5
1899	41/0	44/0 to 100/0	72/0	3/0 to 59/0	31/0	43
1900	61/6	53/6 to 100/0	76/9	−8/0 to 38/6	15/3	20

At the beginning of this century German firms were paying dividends where British firms were not, and in 1903 the *Iron and Coal Trade Review* recorded that in Germany more regular dividends were paid.

TABLE 82

GERMAN PROFITS IN 1903—WESTPHALIA DISTRICT

(Abstracted from data by Jeans)

Product	*Cost of Production Average in Mks.*	*Cartel Home Prices*	*Profit per cent*	*Cartel Export Prices*	*Profit per cent*
Thomas Iron	42·47	57·75	36·0	—	—
Acid Pig	41·00	56·00	36·6	—	—
Basic Imports	54·91	77·20	40·5	71·50	30·5
Siemens Acid Ingots	63·05	—	—	—	—
Basic Blooms	64·60	82·50	27·8	—	—
Basic Billets	71·57	90·00	25·8	76·00	6·2
Basic Girders	77·70	102·50	32 0	80·50	3·6
Basic Rails	78·92	105·00	33·0	83·00	5·2
Basic Plates	96·57	115·00	19·2	107·50*	11·3
Acid Bars	73·50	92·50	25·8	77·50*	5·4
Acid Plates	106·95	120·00	12·2	—	—

* Antwerp

In 1904–06 Jeans could draw no conclusions as to the height of profits in free-trade or protected countries, but he stated that the average profits in Britain were not as high as in other countries and would probably diminish. This, he thought, was due to the expenditure on repairs, renewals and reconstruction not being sufficient to keep the British plants efficient. Per ton of steel manufactured, Britain was not reserving for capital expenditure one-half of that in the U.S.A.

Between 1907 and 1913 there is evidence, as shown in Table 83, that higher profits were being made in Germany than in Britain. In so far as the United States Steel Company can be taken as characteristic of the American industry, high percentage dividends were not being paid but large sums were being allocated to new plant or replacements.

In the U.S.A. the Carnegie Company made $133,000,000 profit between 1875 and 1900 and Carnegie cleared 80,000 per cent in twenty-eight years.

From 1901 to 1913 the United States Steel Co. earned $808.000.000

TABLE 83

INTERNATIONAL COMPARISON OF PROFITS, 1907–13

Dividends on Ordinary Stock

GREAT BRITAIN

	1907–8	*1908–9*	*1909–10*	*1910–11*	*1911–12*	*1912–13*
Baldwins	5	5	5	7½	10	10
Barrow Hematite	2	—	—	—	—	—
Bolchow Vaughan	6	5	6	6	5	10
Cammell Laird	2½	—	—	—	—	—
Cargo Fleet	—	—	—	—	—	—
Dorman Long	6½	4	5	6	7½	8½
Ebbw Vale	10	2½	5	2½	3	10
Guest Keen	10	10	10	10	10	10
Lancashire Steel	5	—	—	—	—	—
Skelton	—	—	—	—	—	—
Steel Co. of Scotland	7½	7½	6	6	10	10
South Durham	5	5	5	10	20	25
Workington	—	—	—	3	—	6

GERMANY

	1907–8	*1908–9*	*1909–10*	*1910–11*	*1911–12*	*1912–13*
Bochum	—	12	12	14½	14	14
Deutsche Lux	—	10	11	11	11	10
Gutchoffnungshutte	—	20	20	20	20	20
Maxmillianhutte	—	16	21	23½	30½	30½
Phoenix	—	9	15	15	18	18
Rheinische Stahlwerke	—	6	7	8	10	10
Rombach	—	5	8	9	10	10
Hoesch	—	14	18	20	22	24

— Means no dividend paid

and paid $546,000,000 in dividends. Average dividends on common stock were as follows:

U.S.A.

Year	*U.S.S. Co. only Common Stock*
1908	3
1909	4
1910	5
1912	5
1913	5

During the War, high profits were earned in the British industry, some indication of which is shown in the following tables of bonus shares paid out of reserves.

TABLE 84

GREAT BRITAIN

Bonus Shares paid to Shareholders, 1914–19, out of Reserves

Baldwins Ltd.	1918	£310,165	One Share for each four held, equal to 25 % Dividend.
Consett Iron Co. Ltd.	1919	£2,000,000	Two Shares for each one held, equal to 200 % Dividend.
Dorman, Long & Co. Ltd.	1918	£240,406	One Share for each 5¼ held, equal to 19 % Dividend.
Guest, Keen & Nettlefold Ltd.	1918	£2,895,000	Three Shares for each one held, equal to 300 % Dividend.
Hadfields Ltd.	1919	£800,000	Two Shares for each one held, equal to 200 % Dividend.
J. Lysaght Ltd.	1919	£1,600,000	Four Shares for each one held, equal to 400 % Dividend.
North Lonsdale Iron and Steel Co.	1918	£30,000	30d. per £10 Share, £8 10s. paid-up, equal to 17½ % Dividend.
Parkgate Iron & Steel Co.	1917	£100,000	One Share for each four held, equal to 25 % Dividend. (Also gave a Bonus of £100,000 in 1913, and has now watered down the capital by converting each Share into three of the same value.)
Pearson & Knowles	1918	£366,000	Three Shares for each five held, equal to 60 % Dividend.
Pease & Partners	1918	£230,000	One Share for each five held, equal to 20 % Dividend.
Sheepbridge Coal & Iron Co.	1918	£334,631	One Share for each three held, equal to 33⅓ % Dividend.
Tredegar Iron and Coal Co.	1918	£412,167	One Share for each two held, equal to 50 % Dividend.
Bengal Iron & Steel	1919		Ordinary Shares exchanged, one for five new and one other at par. 6 % Debentures exchanged, one for 7½ % Debentures.

In the data on dividends paid by representative steel companies in Britain (Table 85, pp. 254–5), the fall in profits after 1920 is shown—practically to vanishing point in the latter part of the decade. Some information is also given in the tables on the profits in foreign iron and steel industries, and it will be noted that in Germany after 1924 dividends were being paid which averaged 5 to 7 per cent,

and they were only paid after making ample allowance for depreciation and reserve. Continental firms had, in fact, adopted a policy of re-investing a substantial proportion of their gross profits in the industry for plant extension and modernization.

French firms were paying satisfactory dividends during this decade and Belgian firms even more. The average for the American industry was about 7 per cent.

The firms listed represent 70 per cent of the pig iron capacity and 60 per cent of the steel capacity. It will be noted that a large number of firms, representing 40 per cent of the iron and steel output, paid no ordinary dividend from 1921 to 1929.

Germany

German net profits, from 1913 to 1925, are indicated by those of some representative firms, in Table 86 (p. 256).

The average profits of leading steel companies in Germany were:

1925–26	5 per cent average.
1926–27	6 per cent (The Vereinigte Stahlwerke paid 6 per cent and spent £5 millions on extensions.)
1927–8–9	6 per cent. Six of the principal Ruhr firms averaging £11·5 millions capital—Ver; Stahl; Mannesmann; Krupp; Klockner; Hoesch, and Gutehoffnung, paid 6 to 8 per cent dividend after placing large sums to reserve; Charlottenhute 12 per cent.

The profits of some individual firms were as follows:

	1925–26 *Per cent*	*1926–27* *Per cent*	*1927–28* *Per cent*	*1928–29* *Per cent*	*1929–30* *Per cent*
Hoesch	5	8	6½	7	6
Klockner	5	7	6	7	6
Mannesmann	4	8	7	7	—
V.S.W.	3	6	6	6	—

In 1928–29 the Stahlwerke Becker paid 10 per cent.

France

Some dividends paid by large firms were:

	Per cent	
	1928–29	*1929–30*
Denain et d'Anzin	5·0	7·4
Marine et Homecourt	3·9	3·9
Longwy	6·2	6·1
Schneider-Creusot	7·5	7·7
Senelle-Maubeuge	6·8	7·2

TABLE 85

GREAT BRITAIN

DIVIDENDS PAID BY REPRESENTATIVE STEEL COMPANIES

COMPANY:	Paid up Capital (Ord.)	1913	1914	1915	1916	1917	1918	1920	1921	1922	1923	1924
	£	%	%	%	%	%	%	%	%	%	%	%
Baldwins Ltd	3,451,644	10	10	10	12½*	12½*	11½*	12½*	5*	nil	nil	nil
Cammell, Laird & Co.	1,147,670	7½	10	10	10	10	10	7½	5	5	nil	nil
Consett Iron Co. Ltd.	3,000,000	80	30	12½	50	40*	40*	12½*	10*	4*	5*	7½*
Dorman, Long & Co. Ltd.	1,500,000	8½	7½	13	14	8*	13*	10*	5*	nil	nil	nil
Guest, Keen & Nettlefold Ltd	2,895,000	15	15	15	15	15	15	15*	10*	10*	10*	10*
Hadfields Ltd	400,000	20	22½	25	30*	30*	30*	5*	5*	5*	4	nil
Pearson & Knowles	610,000	8	5	7½	15	15	15	10	10	5	5	nil
Stewarts & Lloyds Ltd.	850,000	12½*	12½*	12½*	12½*	12½*	12½*	15*	12½*	12½*	12½*	10
Ebbw Vale	—	—	—	—	—	—	—	15	5	nil	nil	nil

* Free of tax.

The fall in profits from 1928 onwards is brought out in the following table issued by the N.F.I. & S.M.

STATEMENT SHOWING DIVIDENDS PAID ON ORDINARY SHARE CAPITAL OF TWENTY-SEVEN IRON AND STEEL COMPANIES, 1911 TO 1913 AND 1923 TO 1928

	1907 1908	1908 1909	1909 1910	1910 1911	1911	1912	1913	1923	1924	1925	1926	1927	1928
	%	%	%	%	%	%	%	%	%	%	%	%	%
Armstrong Whitworth & Co. Ltd.	—	—	—	—	12½	12½	12½	5	5	—	—	—	—
Baldwins Ltd.	5	5	5	7½	10	10	10	—	—	—	—	—	—
Barrow, Hematite Steel Co.	2	—	—	—	—	—	—	—	—	—	—	—	—
W. Beardmore & Co. Ltd.	—	—	—	5	5	5	5	—	—	—	—	—	—

Blaenavon Co. Ltd.		—	—	—	—	—	—	5	—	—				
Bolckow, Vaughan & Co. Ltd.		6	5	6	6	5	10	6	—	—	—	—	—	—
J. Brown & Co. Ltd.		—	—	—	—	7½	7½	10	5	5	—	—	—	—
Cammell, Laird & Co.		2½	—	—	—	—	—	2½	—	—	—	—	—	—
Cargo Fleet Iron Co. Ltd.		—	—	—	—	—	—	—	—	—	—	—	—	—
Coltness Iron Co. Ltd.		—	—	—	—	10	15	8	5	10	7½	10	10	5
Consett Iron Co. Ltd.		—	—	—	—	45	60	30	7½*	2½	—	—	—	—
Dorman, Long & Co. Ltd.		6½	4	5	—	6	7½	8½	—	—	—	—	—	—
Ebbw Vale Steel, Iron & Coal Co. Ltd.		10	2½	5	2½	3	10	10	—	—	—	—	—	—
Guest, Keen & Nettlefolds Ltd. C B.		10	10	10	—	10 5	10 5	10 5	10	10	10	10	10	10
Hadfields Ltd.		—	—	—	—	17½	20	20	4	2½	3	2½	5	2
Millom & Askam Co. Ltd.		—	—	—	—	7	8½	12	—	—		—	—	
Palmers' Shipbuilding & Iron Co. Ltd.		—	—	—	—	—	—	—	—	—	—	—		—
Pease & Partners Ltd.		—	—	—	—	8	12	12	8	1½	—			
Scott, Walter & Co. Ltd.		—	—	—	—	—	10	5	—	—	—	—		
Scottish Iron & Steel Co. Ltd.†.		—	—	—	—	—	—	—	6	4	5	—	8	5
Sheepbridge Iron & Coal Co. Ltd.		—	—	—	—	10	20	15	7½	5	5	7½	2½	2½
South Durham Steel & Iron Co., Ltd.		5	5	5	—	10	20	25	10	10	10	5	5	6
Staveley Iron & Coal Co. Ltd.		—	—	—	—	10	25	12½	10	7½	5	7½	5	5
Stewarts & Lloyds & Co. Ltd.	P.	—	—	—	—	?	?	10	10	10	10	10	10	10
,, ,, ,,	D.	—	—	—	—	10	10	12½	12½	12½	7½	2½	5	5
Thomas R. & Co. Ltd.		—	—	—	—	?	?	?	3¾	5	2½			
United Steel Co. Ltd.		—	—	—	—	?	?	?	—	—		—		—
Vickers Ltd.		—	—	—	—	10	10	12½	—	—		—	8‡	8‡

* Nine months
† Company formed June 1912
‡ After reconstruction
— No dividend paid.

C.B. Cash Bonus
P. Preferred Ordinary
D. Deferred Ordinary

TABLE 86

GERMANY—DIVIDENDS PAID BY REPRESENTATIVE COMPANIES

MILLION MARKS

	Total Trading Capital		Gross Profits		Net Profits Including Carry-over	
	1913–1914	*1924–1925*	*1913–1914*	*1924–1925*	*1913–1914*	*1924–1925*
Kloecknerwerke	—	125·75	—	6·78	—	0·45
Mannesmann	116·05	135·75	12·49	9·66	6·86	2·74
Gutehoffnungshutte	94·51	66·00	14·51	5·11	7·59	0·89
Phoenix	161·61	352·28	36·26	23·34	31·70	1·21
Rheinstahl	67·58	230·15	10·01	7·96	5·90	0·35
Krupp	346·91	304·43	18·29	55·01	14·83	—
Hoesch	63·39	83·35	7·0	9 06	6·19	0·78
Van Der Zypen	24 94	25·02	2·78	3·59	3·11	1·77
Bochumer Verein	64·97	73·02	6·95	9·80	4·36	0·13
Deutsch-Lux	250·52	137·83	11·01	24·39	8·92	1·91

BELGIUM

Some recent dividends have been as follows:

	1926–27	*1927–28*	*1928–29*	*1929–30*
Arbed	25·0	24·3	28·8	33·3
Cockerill	7·8	9·7	9·7	7·8
Hadir	16·0	16·0	18·0	22·0
Providence	19·5	27·3	54·6	54·6
Ougree Marihaye	11·7	17·0	20·0	20·0

The relation of dividends to wages before and after the War is given in the following figures expressed in gold francs:

	Wages	*Gross Profits*	*Net Profits*
1912–13	71·25 millions	22·87 millions	21·95 millions
1920–21 to 1927–28	94·99 millions	14·24 millions	11·81 millions

U.S.A.

NET EARNINGS PER CENT

Year	*Average*	*U.S.S. Co. only (Common stock)*
1916	14·9	—
1917	28·9	—
1918	20·0	—
1924	4·91	—
1925	5·61	12·36
1926	6·86	13·92
1927	5·22	—
1928	6·55	—
1929	10.50	13·83
1930	—	16·98

The earnings of the U.S.S.C. were below those of the average steel company but above those of the pure pig iron and coke industries. Thus:

	Per cent Earnings	
	1926	*1927*
23 Companies with U.S.S.C.	7·3	[illegible]
22 Companies without U.S.S.C.	[illegible]	[illegible]
4 Companies making pig iron and coke	6·1	3·6

Between 1923 and 1929 eighteen steel companies paid 44·2 per cent on their common stock.

For the ten largest steel companies the earnings available for interest and dividends, per ton of ingots, were as follows:

1913	$6·13
1924–5–6	6·21
1926	6·69

and the earnings as a percentage of the capitalization of twenty-two companies were:

1926	6·7
1927	5·22
1928	6·55
1929	10·50

General Industrial Profits

Table 87 (p. 258) gives the Economist Chain Index from 1908 to 1930, and the ten year moving average shows that, without correcting for price changes, the index rose from 62 in 1913 to about 105 for 1923–30. In view of the practically profitless working of the iron and steel industry during the latter years, it must have been subject to handicaps not characteristic of British industry as a whole, which confirms the contention that internal conditions of the iron and steel trade were affecting its decline.

Was there a Weak Factor in Capitalization?

We have now to enquire if in Britain capital was a scarce factor in production; in other words, was any burden placed on the British iron and steel industry in respect of capitalization as compared with the industries in foreign countries?

This question of capitalization is complex. The capitalization of a plant does not determine if it is worth working from an industrial point of view, but only determines if it will pay a dividend. Although

TABLE 87

ECONOMIST PROFITS CHAIN INDEX

Year	Economist Chain Index (1925 = 100)		Schedule "D" Assessment Index	Wholesale Prices	
	Annual	10-year moving average		Annual	10-year moving average
1908	35·9	—	34·9	87	—
1909	37·5	—	36·5	88	—
1910	42·5	—	37·4	93	—
1911	44·3	—	39·3	96	—
1912	49·2	57·3	41·9	101	116·4
1913	63·7	62·5	45·3	101	130·7
1914	59·9	69·5	45·8	101	146·5
1915	71·9	76·9	62·4	129	167·2
1916	83·5	79·2	70·3	161	176·1
1917	84·2	82·1	81·9	207	181·6
1918	88·6	84·4	94·6	230	186·9
1919	107·2	88·0	113·5	246	193·3
1920	117·0	91·1	123·2	300	196·5
1921	67·0	92·8	119·5	185	195·6
1922	77·8	95·0	106·1*	156	189·2
1923	86·9	107·0	105·8	154	180·5
1924	95·6	107·5	108·9	165	169·6
1925	102·8	105·4	110·2	161	151·1
1926	100·7	105·7	106·7	150	142·7
1927	106·5	104·6	112·0	145	136·4
1928	108·3	103·3	114·1	143	130·5
1929	112·5	102·9	112·8	137	123·7
1930	95·9	103·4	101·6	115	117·6

* Excluding Eire from this date.

it should not exceed earning capacity, promoters find a particular temptation to over-capitalize in mergers.

Data on the capitalization of the iron and steel industries in the various countries considered are lacking in most cases, but it is obvious that during the period under review the invested capital must have increased very greatly in all. In Britain the increase was probably of the order of ten times, and Lord Aberconway estimated that the capital of Sheffield steel firms making heavy products increased from £4 to £40 millions between 1861 and 1927. The capital of the industry on the north-east coast increased from £13 to £32 millions between 1913 and 1925.

The productive capacity of the industry did not increase in the same proportion as the cost of plant per ton of finished steel increased. According to Harbord this was £4 to £4 10s. in 1890 and £6 10s. to £7 in 1912, whilst after the War it was £10 to £12 per ton. Another estimate of the cost of plant per ton of finished steel capacity in 1910–12 was £9 to £10, but on the Continent it is believed to have been lower than in Britain. In 1904 Jeans said that the standard of capitalization should be the productive capacity of the plant and suggested one ton of pig iron per annum for every £1 invested, and one ton of merchant steel for every £1 5s. to £1 10s. invested, but he was obviously optimistic.

It can be stated that there was no lack of capital in Britain at the beginning of the period as profits were high in the early seventies, and at the end of the decade and the beginning of the eighties new plants were being built.

In the eighties also the industry was prosperous due to the demand for steel for railways, mining, bridges and docks and in the electrical industry, and the capital invested in the industry was expanded but not in well-judged directions.

Towards the end of the century British capital costs were said to be high and capital was mainly derived from personal contacts, but there was no indication of starvation of capital and in 1903 Bell said that much money was being spent on plant improvements. This remained broadly the position and there was little or no evidence that the capital costs, which the products had to carry, were burdensome.

Nevertheless for new plants, British industry had less satisfactory access to capital resources and less efficient financial mechanisms for handling reorganization and amalgamation than existed on the Continent.

The large outlay needed to initiate competition in the iron and steel industry explains the difficulty in the formation of new firms and why, without the practical assistance and participation of the banks, the industry tended to remain a family affair.

In Germany a good deal of money was invested in iron and steel works at the beginning of the period, stated to have been about 95 million thalers per annum. The capital costs were stated, however, to be higher than in Britain. In 1896 the British Iron Trade Association reported that German iron and steel firms were capitalized at a lower cost per ton of output than were British firms.

In the decade 1904–14, firms grew up rapidly in Germany and

tended to be over-capitalized. The German drive to increase exports during this period was a reflex of the necessity to obtain returns on this large capital. From the end of last century German works were said to have a smaller nominal capital than British in relation to the scale of their operations and this was no doubt associated with their better lay-out for large-scale production.

In Belgium, also (if the Société Cockerill* may be taken as typical), the capitalization was lower per ton of capacity than the British. Data on the capitalization of the French industry are not available.†

At the beginning of the 20th century over-capitalization in the U.S.A. was a feature of the amalgamations that had occurred. In 1904 Jeans estimated that the United States Steel Corporation was capitalized three times too high, based on the productive capacity of the plants (£3 of capital per ton of output). Much water was subsequently squeezed out, however, by building new plants and purchasing rival plants. Large concentrations of capital being more characteristic compared with Britain, the specialized plants were more productive per £1 invested and there was a greater chance of earning dividends than in this country.

1914–30 IN BRITAIN

The construction of iron and steel works received a powerful stimulus from the war. The object of the Ministry of Munitions was to supply up-to-date plants at pre-war costs, but the plans were naturally directed to immediate production and had little or no bearing on efficient peace-time development, so that the plants in this country were not well proportioned or economically coupled. Instead of new blast furnaces the old ones were patched up and the cost of new steel melting capacity fell mainly on the manufacturers.

The nominal value of the iron and steel companies' shares rose up to 1920, when the British industry was capitalized at approximately £250 millions, the different types of shares increasing proportionately.

* In 1894–95 the capital was £1,000,000 for 9,753 men engaged (per the Iron Trade Association).

† From the Secretary of the Comité des Forges:

15*th* June, 1931.

MONSIEUR,—

En reponse à votre demande du 1er juin, nous avons le regret de vous informer que nous ne possedons pas les renseignments necessaires pour vous documenter utilement sur la capitalization de l'industrie siderurgique française, avant et depuis la guerre.

LE SECRÉTAIRE GÉNÉRAL.

There was a good deal of money available for investment during the inflation years and the steel makers thought they could use it profitably as undivided profits were also reinvested. Much of the capital increase was due to amalgamations and fixed interest indebtedness increased, though the total nominal capital fell. Debentures, some for short periods, as in 1921–24, became a growing burden on the industry. Some of the over-investment was caused by underestimating the cost of plant extensions.

By 1925 dividends were rarely paid and little was being put away for depreciation.

With currency deflation and the return to gold, capital charges became a heavy burden on the industry, out of all proportion to the post-war value of the plants and considerable writing down became necessary. In 1930 the capitalization of the industry was estimated at £200 millions, consisting of about one-half ordinary shares, one-quarter preference shares and one-quarter debentures.

The burden became heavier as the industry worked shorter and shorter of capacity, especially on the technically efficient plants where the percentage overhead costs were higher.

The allowance made for wear and tear by the Inland Revenue Authorities was quite inadequate and capital values were not maintained. Ordinary shares sank to very low values and the industry became discredited as a field of investment for capital. Many firms had to undergo financial reconstruction, but in spite of this there was a wide margin in 1930 between actual and nominal share values.

In 1930 the sub-committee of the Committee on Civil Research, under the chairmanship of Lord Sankey, said that the coke-making and iron-smelting plant in the industry was wholly inadequate and antiquated, and that £15 millions were necessary for rehabilitation, but there is reason to believe that such a sum would merely have been trifling with the situation.

1918–30 Abroad

Conditions were different abroad in post-war times. The dividends paid were, on the whole, small, but fixed interest charges were paid and sums were put aside for reinvestment. In Germany inflation and the collapse of the currency led to capital being largely written off. A large amount of reconditioning took place and up-to-date plant and equipment were installed. Credit was subsequently contracted, but in spite of the handicap on borrowing, rationalization

assisted in keeping down the capitalization per unit of output. After 1927 iron and steel shares fell in value, showing that there was a tendency in the German industry to be over-capitalized, though general monetary conditions and the world slump were no doubt contributory.

In France reparation payments and the depreciation of the franc were utilized to reconstruct and modernize plants and "write down" capital. Whilst rationalization was in full swing in Germany, France made only such changes and additions as were absolutely required, thus minimizing capital charges as far as possible. The plants of Alsace-Lorraine had been transferred to French owners at a fraction of their capital value and the capital issues made to acquire these properties led to some of the concerns getting into the hands of the banks. Low capital charges were characteristic, however, of the French iron and steel industry. In addition to making adequate provision for amortization the French manufacturers adopted the policy of re-investing a substantial proportion of their gross trading profits in the industry.

In Belgium capital expenditure after the war was eased by reparation payments. For example, the cost of reconstruction of twelve of the principal works was 908 million francs, towards which 628 million francs were received in reparations, making the cost to Belgium only about 260 million francs. Not only was capital secured and plants modernized from reparations, but State aid was given and new capital issues kept within bounds.

In the U.S.A. the industry was active and prosperous until the slump in 1929. In the post-war period considerable sums were put back into the industry from gross profits, but investments increased and over-capitalization continued, and with the slump share values fell considerably in 1929–30. In 1926 £950,000,000 was estimated to be invested in steel works and in 1927 the value of the industry was taken at £1,200,000,000, and it was higher still in 1928. A British estimate of £1,000,000,000 was probably conservative. In 1928 the capitalization per ton of ingot capacity was £16, but it fell somewhat (£15 10s.) the next year.

	1926	*1927*	*1928*	*1929*
Number of companies	25	22	22	22
Capitalization (million dollars)	3,954	3,961	4,016	3,817
Common stock	1,144	1,341	1,352	1,366
Preferred stock	689	689	670	700
Funded debt	1,027	923	932	1,022
Surplus	1,082	1,017	1,016	727

	1926	*1927*	*1928*	*1929*
Capitalization per ton capacity, $	70	80·1	80·0	77·8
Total assets, million dollars	4,423	4,572	4,557	4,652
Earnings per cent of capitalization	6·7	5·42	6·55	10·50
Net earning, million dollars	213	178	216	352
Ingot capacity, million tons	49·0	49·0	49·7	52·0

Banking

At the beginning of the period the sources of long-term capital for the British industry were private fortunes and public investments, only short-term advances being made by the banks. Iron and steel firms were unable to contact the long-term loan market and the practicability of amalgamation, integration and concerted action was limited.

Very few ordinary shares were subscribed in London after the seventies and, whilst it was known that big private fortunes had been made in the industry, there was a distrust amongst investors both of the industry and of steel company promoters. (Nash, *Inquiries into the Profitable Nature of our Investments, 1880.*)

As the period developed and firms became larger, either from natural growth or combination and integration, the capitalization of some companies increased considerably. Long-term capital was still obtained, however, through Issuing Houses, and there was a reluctance on the part of the industry to risk bank control, even if British bankers had considered long-term financing of trade as a legitimate banking function.

Between 1897 and 1902 the Berlin Bourse advanced £29 millions to iron and steel firms, compared with £16 millions advanced in London to British firms through Stock Exchange issues. In 1904 Jeans referred to the difficulties of raising capital and reiterated that capital could be obtained for the iron and steel industry more easily in Berlin than London. The unreadiness of the banks to advance money for the purchase of new plant and equipment was undoubtedly a factor in the non-emergence of large-capacity plants.

In Britain after the war the intervention of bank capital was held off as long as possible, but in the twenties, when iron and steel prices were below the general price level and falling continuously, debentures fell more and more into the hands of the banks and they were forced to take an interest in the industry. A large part of the firms were living on frozen overdrafts and under the legal control of the banks, which did not possess the experience to exercise positive direction.

As the return on investments in the industry were so problematic, the risk was too high for private investors, and it was impossible to go to the capital market for money for reorganization. It was appreciated that only the banks could finance the industry on a scale sufficient for full modernization, and the unparalleled depression forced the banks to take some action to further the schemes for rationalization. The Bank of England, through the Bankers' Industrial Development Company, took the initiative in the amalgamation scheme represented by the English Steel Corporation, while the Securities Management Trust financed the Lancashire Corporation. The banks only visualized, however, regional consolidation and specialization, but had apparently no scheme for the resuscitation of the whole industry.

In the years 1921–30 the real problem was to put the industry into a position to attract capital as a paying investment. Professor Jevons suggested that the State should assist in financing the re-planning of the whole of the heavy industry at economically strategic points in co-ordinated modern plants of sufficient size to obtain the best scientific management, and that it should be run on public utility lines with price control of standard products and an international agreement with regard to output. It was improbable that State aid would be resorted to, but its suggestion was significant as was also the alternative suggestion of providing a stable demand by reservation of the home market.

As regards export trade, the Macmillan report (1931) made reference to the fact that it had not been possible for traders in this country to obtain advances on terms as favourable as in some of the leading competitive countries. It was not until 1926 that a form of financial assistance by credit facilities for export trade was provided by the Export Credits Department of the Department of Overseas Trade. The work of the department was, however, considered a temporary expedient until its schemes could be replaced by the assistance of credit insurance companies.

In contrast with the British view on investment banking, the iron and steel industries in the foreign countries considered received financial service from the banks, quite apart from short-term advances. In Germany and the U.S.A. investment and deposit banking were limited and investment banks handled share issues for iron and steel firms and held their shares as a long-term investment.

In Germany the banks were the chief agencies for the supply of long-period capital, and naturally they favoured the larger firms,

who could better forecast their demand. The banks also used their financial power for carrying through mergers and consolidations.

In Belgium the Bank La Société Générale de Belgique and in France banks like l'Union Parisienne played an important role in the development and finance of the iron and steel industry.

CONCLUSIONS

In summary, there does not appear a great deal of evidence to indicate that the British iron and steel industry suffered much handicap in the supply of capital up to 1913, except in so far as the following factors introduced restrictions:

(1) It was mainly derived from private fortunes and not public subscriptions, as there was some distrust of the industry amongst investors;
(2) The industry was out of touch with the London money market.
(3) The banks did not support and foster its development to the extent to which foreign banks serviced their national industries.

It should be noted, also, that much capital was tied up in Britain in plant and equipment manufacturing a wide range of products, a handicap which increased as the economies of standardization were progressively adopted in foreign countries.

After the War the restriction of capital supplies was partly due to causes beyond the control of the industry, but partly, also, to the position into which it had allowed itself to drift. The latter included small-scale lay-out, obsolescence of plant, unbalanced expansion, unhealthy capitalization of reserves, the over-capitalization of combinations, the mishandling of the post-war boom, and the lack of organization of export sales.

The industry was discredited as a field of investment and the banks, having to intervene against their will, had neither the experience nor the vision to handle the reorganization of the industry with vigour and on the national lines which the situation demanded. Whilst it would be difficult to prove that increased facilities for raising capital would have overcome a lack of competitive power in other directions, it is claimed that a relative weakness has been established in this connection.

CHAPTER IX

Conclusions

(a) Appraisal of Inevitability

One of the first points apparent from the above study of the British iron and steel industry's relative decline is its large measure of inevitability. The fundamental steel-making inventions had been made in this country, and we benefited from the close juxtaposition of ore and coal and their proximity to the coast. Apart from these, there were, by 1880, very few favourable factors to support the development of the industry at as fast a rate as in some other industrial countries.

The greatest reserves of iron ore and coal are located in the United States, and next to these are the West European resources. It was, in fact, in these localities that the greatest iron and steel industries in the world were built up, but it should be noted that a British invention—the basic process of steel making—was responsible for opening up the West European industry, and for accelerating the American industry based on the Lake Superior ores.

In these two centres in particular, population grew at a faster rate than in Britain, and the total income of the U.S.A. and Germany also increased more rapidly. Nor was this all. The faster increase of demand was accompanied by a determination on the part of foreign countries to meet this demand themselves, not only by laying out their industries for large-scale production, but by the erection of protective tariffs behind which development might occur reasonably free from the competition of the older British industry.

The increased rate of industrialization abroad offered an opportunity for the faster growth of the export of British capital goods, but coupled with the means, ability and determination to fill home demand, it had not only the effect of limiting the expansion of the British industry, but it became merely a question of time before the foreign iron and steel industries outgrew in capacity their home demand, and were able to compete, by means of discriminatory prices, against British steel products in other foreign markets. Their procedure was, of course, to charge higher prices in

their relatively inelastic home market and a lower price in the relatively elastic foreign markets. Whilst British export trade with undeveloped foreign countries had actually increased by the end of the period reviewed, it was nevertheless losing ground in these markets. Britain herself, under open market conditions, was also subjected to the impact of the discriminatory export prices of organized industries abroad.

Not only did the British home market increase more slowly than those of some foreign countries, but there was a fall in the amount of real savings in this country available for investment abroad. These foreign investments mainly took the form of exported capital goods fabricated of iron and steel, so that there must have been a diminution in our power to export. In the period following the European War the country was, moreover, having to offer less amounts of capital goods for our essential supplies of raw materials and foodstuffs.

Whether the relatively high cost of transport was a factor outside the control of the iron and steel industry may be debatable, but it was certainly a handicap.

So far as general monetary considerations are concerned, there have not been found any adverse factors affecting British industry relatively to foreign countries up to the War in 1914, but after it the depreciation of foreign currencies, and particularly the over-valuation of sterling on the return to gold in 1925, not only had a depressing effect on British industry, but seriously handicapped our export trade at a time when economic nationalism was rampant.

Taxation and social charges, although the latter were imposed earlier in Germany, were higher in Britain than in competitive countries and constituted a burdensome item in British industrial oncosts, yet their removal would have depressed productivity still further. British industry also suffered relatively to her competitors in the assistance accorded by the banking institutions in regard to long-term investments, and particularly in the financing of export trade. British banks were financial and commercial rather than industrial in outlook and, in fact, took little interest in the long-term financing of industry until collapse was imminent, and then only covertly. Nevertheless, the large joint-stock banks, as well as the merchant banks, have interlocking directorates with industry, so that there could have been no real difficulty in obtaining fresh capital had there been a promise of profitability.

While, therefore, certain domestic factors external to the industry

were adverse, and while the very development of world economy meant the inevitable displacement of Great Britain from its leading position, yet we have seen that the recession went further than may be thus explained. To a large extent the crisis of the British iron and steel industry is the crisis of all capital goods industries in the great industrial nations which have reached the limits of their national and international expansion, though this crisis will come sooner in the older and most industrialized countries, of which Great Britain was the first. This crisis reacts on the industry inasmuch as by threatening profitability it weakens the incentive to boldness, the readiness to modernize, and tends to make the industry run to shelter rather than to seek to strengthen itself.

(*b*) Appraisal of Avoidable Causes

The fact that decline was inevitable does not, however, account fully for its extent nor its direction and proportions. This country was favourably situated in regard to raw materials, and whilst British resources of hematite ores were known to be limited, our native phosphoric ore deposits were extensive. The fact that they were neglected till approaching the end of the period studied was at least a factor within the power of the industry to control. When it was shown that a successful steel industry could be based on the use of low-grade ores, the migration of iron and steel works to the Jurassic deposits should have commenced.

While British engineers were no doubt correct in their strictures on the early basic Bessemer steel, our steel makers took the despairing view that the difficulties would never be overcome until development abroad showed that it was not only suitable for many purposes but in some cases preferable. In point of fact, by the end of the period this class of steel formed a considerable portion of European production and constituted the bulk of British imports. Apart from the fact that such large imports caused a lack of self-containedness, the irony of the position was that, after going through the finishing processes, this condemned class of steel was being sold as the best British products. In addition, it has been shown that during the period under review, whatever the situation now may be, open-hearth steel did involve a cost of several shillings more per ton than the basic Bessemer steel.

Britain was favoured by ample supplies of good coking coal, but our review has shown that, on the average, our coke-oven installations were small, scattered, relatively inefficient and wrongly situated.

There was, in fact, relatively to other countries, a definite lag in the erection of large centralized cokeries alongside blast furnaces with full utilization of coke-oven gas and by-product recovery.

Pig iron production was carried on in comparatively small blast furnaces with low throughput and gross productivity per man. It is, of course, appreciated that this was influenced by the variety of demand, especially at the beginning of the period, when wrought iron was an important part of production; but large blast furnaces were not only more efficient in operation but, suitably coupled with steel works of adequate capacity, would have given rise to savings in production costs, the most important of which was the overall fuel economy possible.

With the patchwork growth of British iron and steel works there is reason to believe that over the whole industry the capital expenditure per ton of capacity was somewhat higher than in Continental countries. Moreover, on the whole, foreign plants were run (in fact they had to be run), nearer to capacity.

On the other hand, the rates of depreciation were lower in this country, partly due to the British engineering tradition of building very durable plant and machinery, partly to the low allowance for wear and tear by the Inland Revenue Authorities which was an inducement to keeping plants in operation as long as possible. The British plants being older would, moreover, be more likely already to be written down in comparison with Continental plants. There is no reason to believe, therefore, that capital charges in this country were unduly high until after the European War, when greatly diminished demand accompanied falling prices, but it is probable that the obsolescence item in capital charges as a reserve for the modernization of plant was far too low. This lack of vision to accumulate reserves in the early part of the period for the modernization of plants, layouts and sites contributed to the almost insuperable difficulties with which the industry was confronted during the heavy depression in the twenties.

The question of large-scale, properly balanced plant was of great importance in steel production. Rolled products could only be made economically on continuous production lines, postulating a high degree of standardization. In Britain the difference in scale of production of steel and wrought iron was not at first appreciated and, whilst the traditional small-scale plants could economically handle specialities and products in short-run demand, they were incapable of producing billets, blooms and bars in bulk demand at

a competitive price, and it was precisely in these semi-finished products that the British steel makers were out-competed by the mass production works established abroad. The patchwork development of British works indicated a lack of appreciation of the fundamental effect on unit direct costs derived from large-scale lay-out, even if this involved a new start. The industry would not accept the dictum that economic by-gones are by-gones, yet it was no use trying to carry over small industrial units into the mass production machine. British costs of production were influenced by the past history of the industry and there was much less readiness compared, for example, with the U.S.A., to take up new methods and processes, or to plan for future demand.

With the rapidly increasing trend in steel consumption in the early part of the period, the planning and equipment of economically situated mass production works should have been carried out between 1880 and 1900 at the latest. It was not only too late in the profitless twenties—it was already too late in 1912, when the War was seen to be inevitable.

Whilst the lag in horizontal and vertical integration in this country must be chiefly attributed to the open market, which put prices under the control of foreign exporters, individualism and the momentum of *laisser-faire* in Britain militated against a planned organization of the industry, and the measure of success attained at the beginning of the period rather cloaked its necessity. One or two trades, such as the rail-makers, overcame the difficulties of horizontal organization and remained permanently affiliated to international cartels. The inability of the industry to organize itself even regionally, until the last decade under review, proved a particular handicap to the development of sales and marketing. Organization, for example, would have put the trades into a stronger position to obtain the requisite financial backing to give long-term credits, such as were enjoyed by the foreign industries.

Vertical integration, when it occurred, was, unfortunately, based on accidental connections and not on technical suitability or economic locality.

Stress has been laid above on the relative lag in planning modernization and productive efficiency, as it is considered far more important than the frequently alleged handicap of high British wages. Higher wages were paid in this country than on the Continent over the whole of the period under review. In the early part of the period the higher money wages were offset by the greater skill,

experience and productivity of the workmen in the typical small plants (i.e. wage costs were actually lower), but as the period advanced productivity became increasingly dependent on and determined by equipment, lay-out and managerial efficiency, and the output per man was equalled by the lower paid workmen on the Continent. We have noted little, if any, reason to believe that wages in this country were unduly raised by trade unions, though after 1918 a certain amount of rigidity was imposed: not so much however, as experienced in transport and other sheltered industries, as the open market conditions reduced the bargaining power of labour in the iron and steel industries. Theoretically the restraint should have been higher in protected countries but there is no evidence of this in regard to Germany.

On the other hand British labour was relatively immobile, due to hereditary connection with the trade, and it would accept relatively low earnings rather than migrate to newly established industries.

The factors in production are: raw materials, labour, capital and "entrepreneurship." We have noted that there was no scarcity in raw materials, though they might have been more efficiently utilized, no proved restraint on wage rates by labour apart from a rigidity imposed in the depression of the twenties, and no marked scarcity of capital except in the last decade of the period, when the industry was generally incapable of making a profit.

The remaining factor is "entrepreneurship" and our study has led us to suggest a weakness in this direction. If a business deteriorates it is of no use blaming anyone except those at the top, and if an industry declines relatively faster than unfavourable external and uncontrollable factors lead one to expect, the weakness can only be attributable to those who are in control of its activities. There is, in fact, good evidence to believe that the British iron and steel industry would not have declined relatively so fast or so far during the period reviewed had the men at the head possessed greater vision and a bolder and more energetic capacity for organization, direction and administration.

APPENDIX I

Appendix to Chapter I

TABLE 88

PIG IRON PRODUCTION (MILLION TONS)

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1870	5·96	1·24	1·16	0·56	1·67	11·84
1871	6·63	1·40	0·85	0·67	1·71	12·54
1872	6·74	1·78	1·20	0·72	2·55	14·44
1873	6·57	1·95	1·36	0·68	2·56	14·68
1874	5·99	1·63	1 39	0·60	2·40	13·50
1875	6·37	1·73	1·42	0·53	2·02	13·61
1876	6·56	1·59	1·41	0·56	1·87	13·46
1877	6·61	1·69	1·48	0·54	2·07	13·86
1878	6·38	1·87	1·50	0·58	2·30	14·18
1879	6·00	1·93	1·38	0·52	2·74	14·10
1880	7·75	2·43	1·70	0·68	3·84	18·16
1881	8·14	2·58	1·86	0·61	4·14	19·34
1882	8·59	2·95	2·01	0·72	4·62	21·11
1883	8·53	3·08	2·04	0·77	4·60	21·34
1884	7·81	3·18	1·84	0·74	4·10	20·00
1885	7·42	3·22	1·60	0·70	4·04	19·33
1886	7·01	3·08	1·49	0·69	5·68	20·27
1887	7·56	3·47	1·54	0 74	6·42	22·19
1888	8·00	3·75	1·66	0·81	6·49	23·41
1889	8·32	3·90	1·71	0·82	7·60	25·11
1890	7·90	4·03	1·93	0·77	9·20	26·75
1891	7·41	4·03	1·87	0·67	8·28	25·28
1892	6·71	4·28	2·02	0·74	9·16	26·07
1893	6·98	4·36	1·97	0·73	7·12	24·38
1894	7·43	4·62	2·04	0·81	6·66	25·20
1895	7·70	4·69	1·97	0·82	9·45	28·50
1896	8·66	5·47	2·30	0·94	8·62	30·22
1897	8·80	5·91	2·44	1·02	9·65	32·51
1898	8·61	6·26	2·48	0·96	11·77	35·30
1899	9·42	7·05	2·54	1·01	13·62	39·39
1900	8·96	7·43	2·67	1·00	13·79	39·81
1901	7·93	6·85	2·35	0·75	15·88	39·81

TABLE 88—*continued*

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1902	8·68	7·33	2·37	1·05	17·82	43·36
1903	8·94	8·66	2·79	1·20	18·01	45·73
1904	8·69	8·72	2·93	1·27	16·70	44·71
1905	9·61	9·35	3·02	1·29	22·99	53·24
1906	10·18	10·66	3·26	1·35	23·31	58·03
1907	10·11	11·21	3·53	1·38	23·78	59·68
1908	9·06	10·34	3·35	1·25	15·94	47·56
1909	9·53	10·91	3·52	1·59	25·80	59·45
1910	10·01	12·89	3·97	1·82	27·30	64·76
1911	9·53	13·63	4·40	2·01	23·65	62·76
1912	8·75	15·35	4·86	2·26	29·73	72·37
1913	10·26	16·49	5·12	2·45	30·97	77·90
1914	8·92	12·29	2·65	1·43	23·33	59·35
1915	8·79	10·03	0·58	0·07	29·92	59·70
1916	9·05	11·15	1·47	0·13	39·44	72·82
1917	9·32	11·42	1·71	0·01	38·62	69·76
1918	7·09	10·51	1·29	—	39·06	64·95
1919	7·40	6·19	2·37	0·25	31·02	51·89
1920	8·03	6·93	3·38	1·10	36·93	62·85
1921	2·62	7·73	3·31	0·86	16·69	37·68
1922	4·90	9·25	5·14	1·59	27·22	54·78
1923	7·44	4·86	5·34	2·11	40·36	68·71
1924	7·31	7·68	7·57	2·80	31·41	67·13
1925	6·26	10·01	8·36	2·50	36·70	75·69
1926	2·46	9·50	9·28	3·35	39·37	77·54
1927	7·29	12·90	9·13	3·65	36·57	85·33
1928	6·61	11·62	9·82	3·80	38·16	87·89
1929	7·59	13·19	10·20	3·98	42·61	97·33
1930	6.19	9·54	9·85	3·35	31·75	79·40

TABLE 89

STEEL PRODUCTION (MILLION TONS)

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1870	0·22	0·13	0·08	—	0·04	0·51
1871	0·33	0·14	0·08	0·01	0·05	0·67
1872	0·41	0·19	0·13	0·01	0·11	0·94
1873	0·57	0·25	0·15	0·02	0·16	1·26
1874	0·63	0·32	0·21	0·04	0·20	1·53
1875	0·71	0·32	0·21	0·05	0·38	1·79
1876	0·83	0·37	0·19	0·08	0·55	2·14
1877	0·89	0·39	0·25	0·10	0·60	2·40
1878	0·98	0·46	0·28	0·12	0·73	2·78
1879	1·01	0·51	0·33	0·11	0·94	3·21

TABLE 89—*continued*

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1880	1·29	0·69	0 38	0 13	1·25	4·18
1881	1·78	0·90	0·42	0·14	1·59	5 30
1882	2·11	1·07	0·45	0 18	1·74	6·09
1883	2·01	1·06	0·52	0·18	1·67	6·01
1884	1·77	1·14	0·50	0·18	1·55	5·85
1885	1·89	1·20	0·55	0·15	1·71	6 19
1886	2·26	1·29	0·43	0·16	2·56	7·48
1887	3·04	1·65	0·49	0·23	3·34	9·68
1888	3·30	1·76	0·58	0·24	2·90	9·86
1889	3·57	1·96	0·62	0·26	3·39	11·04
1890	3·58	2·10	0·67	0·22	4·28	12·28
1891	3·16	2·41	0·73	0·24	3·90	11·85
1892	2·92	2·61	0·81	0·26	4·93	12·97
1893	2·95	2·98	0·78	0·27	4·02	12·68
1894	3·11	3·56	0·80	0·40	4·41	14·12
1895	3·26	3·83	0·86	0 45	6·11	16·65
1896	4·13	4·63	1·16	0 59	5·28	18·36
1897	4·49	4·81	1·30	0·61	7·18	21·22
1898	4·57	5·19	1·41	0·64	8·93	24·18
1899	4·86	5·78	1·47	0·72	10·64	27·29
1900	4·90	6·36	1·54	0·63	10·19	27·83
1901	4·90	6·04	1·40	0·51	13·47	30·56
1902	4·91	7·34	1·54	0·76	14·95	33·96
1903	5·03	8·29	1·81	0·95	14·53	35·51
1904	5·03	8·43	2·06	1·05	13·86	35·74
1905	5·81	9·51	2·22	1·18	20·02	44·22
1906	6·46	10·53	2·41	1·37	23·40	50·40
1907	6·52	11·43	2·72	1·44	23·36	52·13
1908	5·30	10·56	2·68	1·18	14·02	40·75
1909	5·88	11·32	2·99	1·55	23·96	53·38
1910	6·37	12·89	3·36	1·91	23·09	59·33
1911	6·46	14·08	3·78	2·15	23·68	59·57
1912	6·80	16·09	4·36	2·47	31·25	71·62
1913	7·66	17·32	4·61	2·43	31·30	75·15
1914	7·84	13·59	2·61	1·37	23·51	59·49
1915	8·55	12·09	1·07	0·10	32·15	65·57
1916	8·99	14·64	1·92	0·10	42·77	77·01
1917	9·72	15·26	2·20	0·01	45·06	80·76
1918	9·54	13·87	1·78	0·01	44·46	75·99
1919	7·89	7·72	2·15	0·33	34·67	57·56
1920	9·07	8·40	3·00	1·23	42·13	71·30
1921	3·70	8·93	3·05	0·78	19·78	43·51
1922	5·88	11·53	4·46	1·54	35·60	67·66

TABLE 89—*continued*

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1923	8·48	6·2[illegible]	[illegible]	[illegible]	44·[illegible]	[illegible]
1924	8·20	9·68	[illegible]·74	[illegible]	[illegible]	[illegible]·23
1925	7·39	12·00	7·[illegible]	2·51	[illegible]	8[illegible]·03
1926	3·60	12·15	[illegible]	[illegible]	48·20	[illegible]
1927	9·10	16·06	[illegible]·16	3·[illegible]	44·[illegible]	100·19
1928	8·52	14·29	9·37	3·84	[illegible]·54	107·91
1929	9·64	15·99	9·55	4·02	56·43	118·40
1930	7·33	11·36	9·30	3·42	40·70	93·33

TABLE 90

PIG IRON PRODUCTION (MILLION TONS)

5-year averages

Years	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1870–74	6·38	1·60	1·19	0·64	2·17	13·40
1875–79	6·38	1·76	1·43	0·54	2·20	13·84
1880–84	8·16	2·84	1·89	0·70	4·26	19·99
1885–89	7·66	3·48	1·60	0·75	6·04	22·06
1890–94	7·28	4·26	1·96	0·74	8·08	25·53
1895–99	8·64	5·89	2·35	0·95	10·62	33·18
1900–04	8·64	7·79	2·62	1·05	16·40	42·68
1905–09	9·70	10·49	3·33	1·37	23·16	55·6
1910–14	9·50	14·09	4·20	1·99	26·99	67·42
1915–19	8·33	9·86	1·48	0·09	35·60	63·82
1920–24	6·06	7·29	4·94	1·69	30·52	58·23
1925–29	6·04	11·40	9·36	3·45	38 68	84·75

STEEL PRODUCTION (MILLION TONS)

5-year averages

Years	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*	*World*
1870–74	0·43	0·21	0·13	0·02	0·11	0·98
1875–79	0·88	0·41	0·25	0·09	0·64	2·46
1880–84	1·79	0·97	0·45	0·16	1·56	5·48
1885–89	2·81	1·57	0·53	0·21	2·78	8·84
1890–94	3·14	2·74	0·76	0·28	4·31	12·78
1895–99	4·26	4·85	1·24	0·60	7·63	21·54
1900–04	4·95	7·28	1·67	0·78	13·40	32·72
1905–09	5·99	10·67	2·60	1·34	20·94	48·16
1910–14	7·02	14·79	3·74	2·06	26·56	65·03
1915–19	8·94	12·71	1·82	0·11	39·82	71·37
1920–24	7·06	8·94	4·47	1·72	36·08	67·33
1925–29	7·65	14·10	8·54	3·46	49·31	101·44

TABLE 91

EXPORTS OF IRON AND STEEL (000 TONS)

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1866	1,683	—	—	103*	—
1867	1,883	—	—	135*	—
1868	1,944	—	—	146*	—
1869	2,569	—	—	124*	—
1870	2,715	—	—	—	—
1871	3,168	—	—	—	—
1872	3,383	—	—	—	—
1873	2,988	—	—	237	—
1874	2,488	250?	—	277	—
1875	2,458	—	—	200	—
1876	2,224	—	—	273	136 ?
1877	2,345	—	—	248 ?	180 ?
1878	2,285	746	—	269	151 ?
1879	2,883	893	—	330	141 ?
1880	3,793	772	100	355	174 ?
1881	3,820	891	—	360	8 ?
1882	4,354	971	—	437	10 ?
1883	4.043	1,034	—	422	—
1884	3,497	970	—	411	—
1885	3,131	948	30	396	—
1886	3,388	1,131	—	434	—
1887	4,143	1,174	—	442	—
1888	3,967	970	—	465	—
1889	4,186	985	—	533	—
1890	4,001	943	270	470	50
1891	3,129	1,148	—	455	—
1892	2,633	1,116	—	450	—
1893	2,738	1,194	—	453	—
1894	2,567	1,417	—	496	—
1895	2,738	1,504	—	491	89
1896	3,423	1,494	—	583	205
1897	3,599	1,371	—	582	561
1898	3,160	1,600	—	590	797
1899	3,601	1,486	—	569	894
1900	3,447	1,525	110	459	1,154
1901	2,813	2,329	—	481	701
1902	3,474	3,279	—	625	372
1903	3,565	3,439	—	793	327
1904	3,263	2,706	487	716	1,168
1905	3,721	3,297	562	1,044	1,009
1906	4,682	3,614	459	1,048	1,326
1907	5,152	3,478	681	1,041	1,302
1908	4,097	3,643	654	925	964
1909	4,211	3,984	579	1,057	1,240

TABLE 91—*continued*

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1910	4,588	4,797	536	1,441	1,536
1911	4,516	5,298	408	1,260	2,188
1912	4,808	5,951	556	1,472	2,6[illegible]
1913	4,934	6,401	731	1,470	2,907
1914	2,376	3,302	347	753	865*?
1915	—	—	—	—	3,530
1916	—	—	—	—	6,110
1917	—	—	—	—	6,460
1918	—	—	—	—	5,340
1919	—	1,750?	—	—	4,400
1920	3,251	1,700?	871	921	4,709
1921	1,697	1,602	1,602	912	2,172
1922	3,397	2,518	2,937	1,727	1,931
1923	4,318	1,308	2,184	2,496	1,944
1924	3,853	1,535	2,776	3,261	1,711
1925	3,731	3,214	3,949	3,065	1,678
1926	2,988	4,828	4,128	3,708	2,063
1927	4,196	4,322	5,591	4,600	1,943
1928	4,260	4,648	4,975	4,493	2,356
1929	4,380	5,492	4,213	4,521	2,487
1930	3,160	4,472	4,015	3,857	1,629
1931	1,979	3,954	3,546	3,300	840

* To Great Britain. ? Approximate only.

TABLE 92

EXPORTS OF IRON AND STEEL (000 TONS)

5-year averages

Years	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1870–74	2,950	—	—	—	
1875–79	2,440	—	—	260	—
1880–84	3,900	930	—	390	—
1885–89	3,760	1,040	—	450	—
1890–94	3,010	1,160	—	460	—
1895–99	3,300	1,490	—	560	510
1900–04	3,310	2,670	—	610	740
1905–09	4,370	3,610	580	1,020	1,170
1910–14	4,240	5,150	560	1,240	2,080
1915–19	—	—	—	—	5,170
1920–24	3,300	1,730	2,070	1,860	2,490
1925–29	3,900	4,500	4,570	4,070	2,110

TABLE 93

IMPORTS OF IRON AND STEEL (000 TONS APPROX.)

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1870	156	—	—	—	—
1871	160	709	—	—	1,018
1872	230	—	—	—	1,282
1873	190	—	—	—	987
1874	190	—	3,000	—	378
1875	203	—	2,900	—	178
1876	196	—	2,900	—	127
1877	225	—	1,700	—	110
1878	241	567	2,400	18	115
1879	239	—	—	21	689
1880	348	—	—	—	—
1881	349	—	—	—	—
1882	362	364	472	18	—
1883	360	361	444	16	—
1884	344	320 * 787	318	—	—
1885	346	333 * 772	245	—	578
1886	340	266	—	116	1,098
1887	365	282	—	178	1,783
1888	389	347	—	262	914
1889	423	507 * 994	—	319	748
1890	386	596 * 950	—	323	665
1891	377	412	—	—	—
1892	357	349	—	—	—
1893	327	361	113	—	438
1894	358	349	87	—	309
1895	406	316 * 377	—	—	—
1896	460	420 * 344	—	—	—
1897	516	322 524	—	—	162
1898	591	690 483	—	—	146
1899	645	— 778	—	—	175
1900	800	984 923	—	—	210
1901	924	401 358	—	85	220
1902	1,131	269 234	—	73	1,210
1903	1,304	317	—	92	1,180
1904	1,292	339	—	80	266
1905	1,356	322	331	95	420
1906	1,216	690	429	98	577
1907	935	—	—	104	660
1908	1,119	—	—	124	200
1909	1,193	—	—	109	363

TABLE 93—*continued*

Year	*Britain*	*Germany*	*France*	*Belgium*	*U.S.A.*
1910	1,367	215	—	125	510
1911	1,762	—	—	135	260
1912	1,996	328	200	1,040	225
1913	2,231	300	170 * 630	874	253
1914	1,618	—	—	—	284
1915	1,177	—	—	—	282
1916	773	—	—	—	328
1917	496	—	—	—	330
1918	337	—	—	—	170
1919	509	—	—	—	320
1920	1,108	1,200	884	850	420
1921	1,640	648	495	520	135
1922	881	1,830	760	504	577
1923	1,322	1,740	702	525	580
1924	2,429	1,260	698	562	499
1925	2,721	1,180	169	534	840
1926	3,740	1,040	176	603	980
1927	4,406	2,220	128	640	650
1928	2,897	2,080	136	887	700
1929	2,822	1,470	254	980	680
1930	2,908	1,140	479	677	629

* Where two figures are given, sources disagree.

TABLE 94

IMPORTS AND EXPORTS OF IRON AND STEEL INTO AND FROM THE UNITED KINGDOM, 1867–1930 (THOUSANDS)

	Imports		*Exports*	
Year	*Tons*	*Value £*	*Tons*	*Value £*
1867	123	1,498	1,921	17,375
1868	114	1,331	1,947	17,257
1869	119	1,335	2,555	21,855
1870	156	1,635	2,719	23,536
1871	160	1,770	3,029	25,451
1872	230	2,829	3,275	35,340
1873	190	2,746	2,897	37,332
1874	190	2,929	2,444	30,945
1875	203	3,204	2,436	25,644
1876	196	2,879	2,202	20,641
1877	225	2,846	2,323	20,013
1878	241	2,949	2,265	18,269
1879	239	2,783	2,648	18,616

TABLE 94—*continued*

	Imports		Exports	
Year	*Tons*	*Value £*	*Tons*	*Value £*
1880	348	4,044	3,549	27,225
1881	349	4,053	3,697	27,103
1882	362	4,161	4,222	31,091
1883	360	4,360	3,946	28,252
1884	344	4,125	3,429	24,273
1885	346	3,875	3,045	21,449
1886	340	3,491	3,244	21,479
1887	365	3,642	3,854	24,165
1888	389	3,987	3,822	26,020
1889	423	4,444	4,039	28,710
1890	386	4,474	3,852	31,063
1891	377	4,370	3,129	26,523
1892	357	4,025	2,633	21,438
1893	327	3,823	2,738	20,258
1894	358	3,993	2,567	18,467
1895	406	4,374	2,738	19,428
1896	460	5,744	3,423	23,463
1897	516	4,498	3,599	24,405
1898	591	4,999	3,160	22,392
1899	645	5,575	3,601	27,713
1900	800	7,315	3,447	31,623
1901	924	7,562	2,813	25,009
1902	1,131	7,910	3,474	28,877
1903	1,304	8,662	3,565	30,399
1904	1,292	8,217	3,263	28,067
1905	1,356	8,589	3,721	31,826
1906	1,216	8,360	4,682	39,841
1907	935	7,215	5,152	46,563
1908	1,119	7,682	4,097	37,406
1909	1,193	7,972	4,211	38,192
1910	1,367	9,086	4,588	42,977
1911	1,762	11,134	4,516	43,730
1912	1,996	12,958	4,808	48,598
1913	2,231	15,890	4,969	55,351
1914	1,618	10,877	3,884	41,668
1915	1,177	10,806	3,197	40,406
1916	773	11,214	3,295	56,674
1917	496	10,783	2,328	44,828
1918	337	9,708	1,608	36,843
1919	509	11,613	2,233	64,424

TABLE 94—*continued*

Year	*Imports*		*Exports*	
	Tons	*Value £*	*Tons*	*Value £*
1920	1,108	29,017	3,251	128,907
1921	1,640	22,887	1,697	63,604
1922	881	10,419	3,397	60,852
1923	1,322	13,773	4,318	76,156
1924	2,429	22,387	3,851	74,534
1925	2,721	23,999	3,731	68,162
1926	3,740	29,535	2,968	55,077
1927	4,406	34,032	4,196	60,383
1928	2,897	24,147	4,260	66,789
1929	2,822	24,690	4,379	68,002
1930	2,908	23,327	3,157	51,270

TABLE 95

GREAT BRITAIN—TOTAL FOREIGN TRADE

£ Mn.

Year	*Imports*		*Exports*		
	Total	*Retained*	*British*	*Re-Exports*	*Total*
1866	295·3	245·3	188·9	50·0	238·9
1867	275·2	230·4	181·0	44·8	225·8
1868	294·7	246·6	179·7	48·1	227·8
1869	295·5	248·4	190·0	47·1	237·0
1870	303·0	258·8	199·6	44·5	244·1
1871	331·0	270·5	223·1	60·5	283·6
1872	354·7	296·4	256·3	58·3	314·6
1873	371·3	315·5	255·2	55·8	311·0
1874	370·1	312·0	239·6	58·1	297·7
1875	373·9	315·8	223·5	58·1	281·6
1876	375·2	319·1	200·6	56·1	256·8
1877	394·4	340·9	198·9	53·5	252·3
1878	368·8	316·2	192·8	52·6	245·5
1879	363·0	305·7	191·5	57·3	248·8
1880	411·2	347·8	223·1	63·4	286·4
1881	397·0	333·9	234·0	63·1	297·1
1882	413·0	347·8	241·5	65·2	306·7
1883	426·9	361·3	239·8	65·6	305·4
1884	390·0	327·1	233·0	62·9	296·0
1885	371·0	312·6	213·0	58·4	271·4
1886	349·9	293·7	212·7	56·2	269·0
1887	362·2	302·9	221·9	59·3	281·3

TABLE 95—*continued*

	Imports		Exports		
Year	*Total*	*Retained*	*British*	*Re-Exports*	*Total*
1888	387·6	323·6	234·5	64·0	298·6
1889	427·6	360·9	248 9	66·7	315·6
1890	420·7	356·0	263·5	64·7	328·3
1891	435·4	373·5	247 2	61·9	309·1
1892	423·8	359·4	227·2	64·4	291·6
1893	404·7	345·8	218·3	58·9	277·1
1894	408·3	350·5	216·0	57·8	273·8
1895	416·7	357·0	226·1	59·7	285·8
1896	441·8	385·6	240·1	56 2	296·4
1897	451·0	391·5	234·2	60 0	294·2
1898	470·5	409·8	233·4	60·7	294·0
1899	485·0	419·9	264·5	65·0	329·5
1900	523·1	459·8	291·2	63·2	354·4
1901	522·0	453·1	280·0	67·8	347·8
1902	528·4	472·6	283·4	65·8	349·2
1903	542·6	483·1	290·8	69·6	360 4
1904	551·0	480·7	300·7	70·3	371·0
1905	565·0	487·3	329·8	77·8	407·6
1906	607·9	522·7	375·6	85·1	460·7
1907	645·8	553·9	426·0	91·9	518·0
1908	593·0	513·3	377·1	79·6	456·7
1909	624·7	533·4	378·2	91·3	469·5
1910	678·3	574·5	430·4	103·8	534·1
1911	680·2	577·4	454·1	102·8	556·9
1912	744·6	632·9	487·2	111·7	599·0
1913	768·7	659·1	525·2	109·6	634·8
1914	696·6	601·1	430·7	95·4	526·1
1915	851·9	752·8	384·8	99·0	483·9
1916	948·5	850·9	506·2	91·5	597·7
1917	1,064·1	994·4	527·1	69·6	596·7
1918	1,316·1	1,285·2	501·4	30·9	532·3
1919	1,626·1	1,461·4	798·6	164·7	963·3
1920	1,932·6	1,709·8	1,334·4	222·7	1,557·2
1921	1,085·5	978·5	703·4	106·9	810·3
1922	1,003·0	899·4	719·5	103·6	823·2
1923	1,096·2	977·6	767·2	118·5	885·8
1924	1,277·4	1,137·4	800·9	139·9	939·9
1925	1,320·7	1,166·6	773·3	154·0	927·4
1926	1,241·3	1,115·8	653·0	125·4	778·5
1927	1,218·3	1,095·3	709·0	122·9	832·0
1928	1,195·6	1,075·3	723·6	120·2	843·8
1929	1,220·7	1,111·0	729·3	109·7	839·0
1930	1,043·9	957·1	570·7	86·8	657·5

TABLE 96

FOREIGN TRADE 10-YEAR AVERAGES

	Value of Imports (£ Mn.)		Value of Exports (£ Mn.)		Iron and Steel ('000 tons)	
	Total Retained	Iron and Steel	British	Iron and Steel	Imports	Exports
1870–79	305·1	2·65	218·1	25·58	203·0	2,623·8
1880–89	331·2	4·02	230·2	25·98	362·6	3,684·7
1890–99	374·9	4·39	237·0	23·52	442·3	3,344·0
1900–09	495·9	7·95	333·3	33·78	1,127·0	3,842·5
1910–13	611·0	12·27	474·2	47·66	1,839·0	4,720·5
1921–23	951·8	15·69	730·0	66·87	1,281·0	3,137·3
1924–26	1,137·9	25·30	742·4	65·92	2,963·3	3,523·3
1927–29	1,093·8	27·62	720·6	68·06	3,375·0	4,278·3

TABLE 97

EMPLOYMENT IN THE BRITISH IRON AND STEEL INDUSTRY

Data issued by Board of Trade from returns by about 200 firms (covers Iron and Steel Works, not Blast Furnaces, Tin or Sheet Works)

Year	(I) *No. Employed*	(II) *Av. Shifts per man, per week*	(I) × (II) ·000
1906	96,025	5·56	532
1907	97,558	5·58	544
1908	87,874	5·36	470
1909	88,099	5·38	474
1910	90,867	5·50	500
1911	95,006	5·53	526
1912	97,494	5·61	546
1913	105,058	5·54	583

TABLE 98

UNEMPLOYMENT IN THE IRON AND STEEL TRADES (B.F.I.S.I.)

Year	*Average per cent*	*Year*	*Average per cent*
1922	31·6	1927	18·6
1923	19·1	1928	20·8
1924	18	1929	19·6
1925	22·9	1930	25·0
1926	39		

TABLE 99

MEAN ANNUAL PERCENTAGES OF WORKPEOPLE UNEMPLOYED IN UNITED KINGDOM RELATED TO PIG-IRON CONSUMPTION*

* Seventeenth Abstract of Labour Statistics, Cd. 2145. *British and Foreign Trade and Industry*, Cd. 2337, pp. 89–92.

(Abstracted from *Industrial Fluctuations*, by A. C. Pigou)

Year	*1* *General Percentage*	*2* *Engineering, Shipbuilding and Metal*	*3* *Pig-iron Consumption million tons*	*1* *3-year moving averages*	*2*	*3*
1851	3 9	3·9	—	—	—	—
1852	6·0	6·0	—	3·9	3·9	—
1853	1·7	1·7	—	3·5	3·5	—
1854	2·9	2·9	2·8	3·3	3·3	—
1855	5·4	5·4	2·9	4·3	4·4	3·0
1856	4·7	4·9	3·2	5·4	5·5	3·1
1857	6·0	6·1	3·3	7·5	7·7	3·2
1858	11·9	12 2	3·1	7·2	7·4	3·3
1859	3·8	3·9	3·4	5·9	6·0	3·3
1860	1·9	1·9	3·5	3·6	3·8	3·4
1861	5·2	5·5	3·3	5 2	5·5	3·4
1862	8·4	9·0	3·5	6·5	7·1	3·6
1863	6·0	6·7	4·0	5·7	6·2	4·0
1864	2·7	3·0	4·4	3·6	4·0	4·2
1865	2·1	2·4	4·3	2·7	3·1	4·2
1866	3·3	3·9	4·0	4·3	5·1	4·2
1867	7·4	9·1	4·3	6·2	7·7	4·3
1868	7·9	10·0	4·5	7·3	9·3	4·5
1869	6·7	8·9	4·7	6·2	7·8	4·8
1870	3·9	4·4	5·3	4·0	4·9	5·2
1871	1·6	1·3	5·6	2·1	2·2	5·5
1872	0·9	0·9	5·5	1·2	1·2	5·6
1873	1·2	1·4	5·6	1·3	1·5	5·5
1874	1·7	2·3	5·3	1·8	2·4	5·5
1875	2·4	3·5	5·5	2·6	3·7	5·5
1876	3·7	5·2	5·7	3·6	5·0	5·7
1877	4·7	6·3	5·8	5·1	6·8	5·7
1878	6·8	9·0	5·5	7·6	10·2	5·4
1879	11·4	15·3	4·8	7·9	10·3	5·5
1880	5·5	6·7	6·2	6·8	8·6	5·9
1881	3·5	3·8	6·7	3·8	4·3	6·6
1882	2·3	2·3	6·9	2·8	2·9	6·9
1883	2·6	2·7	7·0	4·3	5·3	6·8
1884	8·1	10·8	6·6	6·7	8·8	6·7

TABLE 99—*continued*

	1	2	3	1	2	3
Year	*General Percentage*	*Engineering, Shipbuilding and Metal*	*Pig-iron Consumption million tons*	*3-year moving averages*		
1885	9·3	12·9	6·5	9·2	12·4	6·4
1886	10·2	13·5	6·0	9·0	12·3	6·3
1887	7 6	10·4	6 5	7·6	10·0	6·5
1888	4·9	6·0	7·0	4 9	6·2	6·0
1889	2·1	2·3	7·2	3·0	3·[illegible]	7 0
1890	2·1	2·2	6·8	2·6	2·9	6·9
1891	3·5	4·1	6·6	4·0	4·7	6·5
1892	6·3	7·7	6·0	5·8	7·7	6·3
1893	7 5	11·4	6·2	6·9	10·1	6·3
1894	6·9	11·2	6·6	6·7	10·3	6·6
1895	5·8	8·2	6·9	5 3	7·9	7·1
1896	3·3	4·2	7·7	4·1	5·7	7·4
1897	3·3	4·8	7·7	3·1	4·3	7·7
1898	2·8	4·0	7·7	2·7	3·7	7·9
1899	2·0	2·4	8·2	2·4	3·0	7·9
1900	2·5	2·6	7·7	2·6	2·9	7·7
1901	3·3	3·8	7·3	3·3	4·0	7·6
1902	4·0	5·5	7·8	4·0	5·3	7·7
1903	4·7	6·6	8·0	4·9	6·8	7·9
1904	6·0	8·4	8·0	5·2	7·2	8·2
1905	5·0	6·6	8·7	4·9	6·4	8·4
1906	3·6	4·1	8·6	4·1	5·2	8·5
1907	3·7	4·9	8·3	5·0	7·2	8·2
1908	7·8	12·5	7·8	6·4	10·1	8·2
1909	7·7	13·0	8·5	6·7	10·8	8·4
1910	4·7	6·8	9·0	5·1	7·7	8·7
1911	3·0	3·4	8·5	3·6	4·6	8·4
1912	3·2	3·6	7·7	2·8	3·1	8·5
1913	2·1	2·2	9·3	2·9	3·0	—
1914	3·3	3·3	—	—	—	—

TABLE 100

SHIPBUILDING: VESSELS LAUNCHED (000 TONS)

	Mercantile			*Warships*		
Year	*Britain*	*Abroad*	*World*	*Britain*	*Foreign*	*Total*
1888	838	—	—	—	—	—
1889	1,209	—	—	—	—	—
1890	1,194	—	—	—	—	—
1891	1,130	—	—	—	—	—

TABLE 100—*continued*

Year	*Mercantile*			*Warships*		
	Britain	*Abroad*	*World*	*Britain*	*Foreign*	*Total*
1892	1,109	248	1,358	151	157	308
1893	836	190	1,026	45	133	179
1894	1,046	277	1,323	33	87	120
1895	951	267	1,218	148	100	248
1896	1,159	408	1,567	164	167	331
1897	952	379	1,331	95	133	228
1898	1,367	525	1,893	191	175	366
1899	1,416	704	2,121	168	176	344
1900	1,442	861	2,304	68	192	260
1901	1,524	1,092	2,617	212	255	467
1902	1,427	1,075	2,502	94	184	278
1903	1,190	955	2,145	152	239	391
1904	1,205	782	1,987	127	308	435
1905	1,623	891	2,514	130	233	363
1906	1,828	1,091	2,919	108	254	362
1907	1,607	1,170	2,778	134	187	321
1908	929	903	1,833	74	235	309
1909	991	610	1,602	126	278	404
1910	1,143	814	1,957	134	176	310
1911	1,803	846	2,650	231	538	768
1912	1,738	1,163	2,901	192	342	534
1913	1,932	1,400	3,332	271	405	676
1914	1,683	1,169	2,852	—	—	—
1915	650	550	1,201	—	—	
1916	608	1,079	1,688	—	—	—
1917	1,162	1,774	2,937	—	—	—
1918	1,348	4,099	5,447	—	—	—
1919	1,620	5,224	6,844	—	—	—
1920	2,055	3,806	5,861	—	—	—
1921	1,538	2,803	4,341	—	—	—
1922	1,031	1,436	2,467	—	—	—
1923	645	997	1,643	—	—	—
1924	1,439	807	2,247	—	—	—
1925	1,084	1,108	2,193	—	—	—
1926	639	1,035	1,674	—	—	—
1927	1,225	1,059	2,285	—	—	—
1928	1,445	1,253	2,699	—	—	—
1929	1,522	1,270	2,793	—	—	—
1930	1,478	1,410	2,889	—	—	—
1931	502	1,114	1,617	—	—	—

TABLE 101

Vessels Under Construction on March 31st in the United Kingdom

Not Warships, 000 tons

Year	*Tonnage*	*Year*	*Tonnage*	*Year*	*Tonnage*	*Year*	*Tonnage*	*Year*	*Tonnage*
1882	900	1892	843	1902	1,24[illegible]	1912	2,606	1922	2,200
1883	920	1893	622	1903	974	1913	2,[illegible]03	1923	1,485
1884	656	1894	725	1904	988	1914	1,870	1924	1,460
1885	400	1895	656	1905	1,251	1915	1,390	1925	1,150
1886	390	1896	769	1906	1,401	1916	1,420	1926	840
1887	440	1897	828	1907	1,306	1917	2,005	1927	1,220
1888	594	1898	1,185	1908	847	1918	1,870	1928	1,445
1889	921	1899	1,385	1909	912	1919	2,234	1929	1,450
1890	863	1900	1,260	1910	1,057	1920	3,394	1930	1,000
1891	804	1901	1,303	1911	1,375	1921	3,790	1931	1,700

Appendix to Chapter II

TABLE 102

NATIONAL INCOME AND POPULATION

	(I) National Income (Actual)	(II) National Income (Real 1925–1934 prices)	(III) Col. II Index No.	(IV) Occupied Population	(V) Col. IV Index No.
GREAT BRITAIN					
		1930 prices			
	£mn.	*£mn.*		*Mn.*	
1860–69	899	1,595	100	13 71	100
1870–76	1,177	1,775	111	14·64	107
1877–85	1,242	2,211	138·5	15·61	114
1886–93	1,410	2,548	109·5	16·45	120
1894–1903	1,666	3,146	197	17·82	130
1904–10	1,940	3,560	223	19·49	142
1911–13	2,241	3,975	249	20·58	150
1913	2,339	4,120	258	20·8 (18·4)	152 (134)
1926–30	4,315	4,315	270·5	—	—
1930	4,318	4,318	270·5	— (21·05)	— (153·5)

(Figures in brackets omit Eire.)

Year	(I)	(II)	(III)	(IV)	(V)
UNITED STATES					
Year	*$thou. mn.*	*$thou. mn.*		*Mn.*	
1850	2·42	6·06	—	7·7	—
1860	4·02	10·96	100	10·5	100
1870	7·38	12·4		12·9	
1880	8·25	17·97	153·5	17·4	149
1890	13·24	27·2	232	23·3	199
1900	19·72	40·2	343	29·1	249
1910	32·2	53	453	37·4	319
1913	34·4	52·5	448	39·3	336
1921–25	68·1	62	—	44	—
1926–30	80·6	74·2	—	47·6	—
1930	74·9	70·7	604		418

TABLE 102—*continued*

	(I) *National Income (Actual)*	(II) *National Income (Real 1925–1934 prices)*	III *Col. II Index No.*	IV *Occupied Population*	V *Col. IV Index No.*
	(Thou mn.				
	GERMANY				
	Md. marks	*Md. marks*		*Mn.*	
1854	11·1	16·25	100	10·7	100
1876	19·85	30·52		13·32	
1877–85	20·83	36·92	158	14·21	118·5
1886–93	23·82	44·09	188·5	15·86	132
1894–1903	29·06	53·5	229	18·38	153
1904–10	39·14	63·35	271	21·13	176
1911–13	47·77	70·65	302	22·66	189
1913	50·13	73·15	312	23·02	191·5
1925–30	—	63·55	271·5	27·22	227
1930	72·5	67·2	287	—	—
	FRANCE				
	Md. frs.	*Md. frs.*		*Mn.*	
1850–59	16·6*	96·2	77·2	14·25	95
1860–69	21·4	124·6	100	15	100
1870–79	26·9	153·4	123	14·5†	96·7
1880–89	28	173·4	139	15·2	101
1890–99	29·5	205·4	165	15·8	105
1900–09	35·5	245	196·5	17	113
1911	38·5	246	197·5	17·7	118
1925–30	224	224	180	18·24‡	121·5
1930	270	235	188·5	18·24	121·5

* Unreliable. † Excluding Alsace-Lorraine onwards ‡ Including Alsace-Lorraine onwards

TABLE 103

CALCULATION OF REAL INCOME

GREAT BRITAIN

Year	(I) *Price Level 1913 = 100*	(II) *Price Level 1930 = 100*
1860–69	98	56·3
1870–76	117·7	67·7
1877–85	97·8	56·2
1886–93	96·3	55·4
1894–1903	92·3	53
1904–10	94·7	54·5
1911–13	98·2	56·4
1913	100	57·5
1930	173·8	100

Actual National Income was converted into real Income by dividing it for each year by price index × 100.

TABLE 104

National Income produced per head of Working Population (in work and unemployed) on basis of 48-hour week

In International Units (I.U.) = $1 U.S.A. at 1925–34 prices

Year	*U.S.A.*	*Great Britain*	*France*	*Germany*
—	—	—	189 (1845)	—
1850	582	—	262 (1855)	288 (1854)
1860	769	521 (1865)	322 (1865)	—
1870	730	546 (1873)	410 (1875)	460 (1876)
1880	813	687 (1881)	469 (1885)	—
1890	958	750	551 (1895)	575
1900	1,161	865 (1899)	630 (1905)	618 (1899)
1907	1,213 (1909)	901	—	652
1910*	1,198	—	—	—
1911*	1,197	—	629	—
1912*	1,191	953	—	688
1913*	1,190	966	629	704
1914*	1,207	—	—	—
1915*	1,294	—	—	—
1916*	1,376	—	—	—
1917*	1,397	—	—	—
1918*	1,306	—	—	—
1919*	1,254	—	—	—
1920*	1,202	—	512	—
1921*	1,223	—	586	—
1922*	1,275	—	630	—
1923*	1,362	—	656	—
1924*	1,433	—	674	—
1925*	1,468	1,048	672	—
1926*	1,492	1,069	660	627
1927*	1,523	1,073	669	659
1928*	1,544	1,102	685	666
1929*	1,515	1,110	695	665
1930*	1,388	1,082	687	643
1931*	1,164	1,015	680	609
1932*	1,014	990	681	580
1933*	1,015	1,019	660	587
1934*	1,130	1,090	—	632
1935*	1,287	1,145	—	688
1936*	1,389	1,206	—	754
1937	1,485	1,275	—	828

* Three-year moving average for U.S.A. from 1910, other countries from 1921

TABLE 10[illegible]

VALUE OF FOREIGN TRADE Mn

Year	British £	Germany R.M.	France Frs.	Belgium Frs.	Year Average	U.S.A. $
1870	547·4	—	6,954	[illegible]	1876–80	1,541
1875	655·5	—	9,259	2,408	1881–85	1,567
1880	697·6	5,726	10,725	2,897	1886–90	1,464
1885	642 4	5,776	8,885	2,547	1891–95	1,768
1890	749 0	7,473	10,292	3,109	1896–1900	2,293
1895	702·5	7,439	9,508	3,066	1901–05	2,881
1900	877·5	10,377	11,510	4,138	1906–10	3,530
1905	1,212·4	12,861	12,363	5,402	1910–14	4,296
1910	972·6	16,409	17,207	7,672	1911–15	4,703
1913	1,403·5	20,867	19,984	8,765	1913	4,932
1920	3,489·8	—	97,225	21,804	1915–20	12,938
1923	1,982·0	—	—	22,929	—	—
1924	2,218·3	—	—	31,577	—	—
1925	2,248·1	21,652	120,807	32,678	1921–25	8,707
1926	2,019·2	20,417	—	43,000	—	—
1927	2,040·2	25,029	—	55,834	—	—
1928	2,039·4	26,277	105,748	63,014	1926–30	9,465
1929	2,059·7	26,930	108,359	67,502	—	—
1930	1,701·4	22,429	95,346	57,381	—	—
1909–13	—	—	13,951	—	—	—
1922–26	—	—	80,385	—	—	—

TABLE 106

SUMMARY OF TARIFFS ON IRON AND STEEL, 1870–1930

(1) FRANCE: Francs per 100 kg.

	1870–73	1874–81	1882–92	1892–1910	1910–28
Ore	Free General Conventional	Free General Conventional	Free General Conventional	Free General Conventional	Free General Conventional
Cast Iron	4·8 & 2·0	Increased by 4 %	2 & 1·5	2 & 1·5	2·25 & 1
Bar Iron	12·0 & 6·0		6 & 5	6 & 5	7·5 & 5
Iron Sheets (black)	24 & 7·5		7·5 & 7	7·5 & 7	10·5 & 7
Iron Sheets (tinned)	48 & 13		13 & 12	14 & 12	14 & 12
Iron Wire	36 & 10		10 & 10	8 & 7	10·5 & 7
Steel Bars	36 & 9		6 & 6	6 & 5	7 5 & 5
Steel Sheets	60 & 4·25		9 & 9 upwards	7·5 & 7	10·5 & 7
Steel Tinned	90 & 15		15 & 15	19 & 15	14 & 12
Steel Wire	84 & 20		20 & 20	40 & 30	10·5 & 7
Rails				7 & 6	9 & 6

The comparison is limited to elementary manufactured products as there have been changes in classification as well as in rates.

(2) GERMANY

The course of German iron and steel tariffs is illustrated by the following figures for pig iron:

Year	*s.*	*d.* *per ton*	
1860	20	5	
1865	15	3	
1868	10	2	
1870	5	0	
1873–76	free		
1878	10	0	The Bismarck Tariff
1902	—		The Bulow Tariff
1914	10	0	
1924	11	0	
1925	10	0	The Bulow Tariff restored
1930	10	0	

(3) U.S.A.

Iron and Steel Tafiff

$ per 100 lb.

	1883	*1890*	*1894*	*1897*	*1909*	*1913*	*1922*
Iron Ore	0·75	0·75	0·40	0·40	0·15	free	free
Pig Iron	6·72	6·72	4·00	4·00	2·50	free	0·75
Steel Rails	20·16	13·44	7·84	7·84	3·92	free	2·24
Structural Shapes	1·25	0·90	0·60	0·50	0·40	10 %	0·20
Tinplate	1·00	2·20	1·20	1·50	1·20	15 %	1·00

Comparison of Pre- and Post-war Tariffs

Article	*1913 Tariff*	*1922 Tariff*
Pig Iron	free	75 c. ton
Bar Iron	5 % av.	0·2 to 1·5 c.
Steel Ingots	Free—15 % av.	20 % av.
Boiler Plates	12 %	20 %
Sheets, Common	12 %	20 %
I. and S. Sheets	15 %	0·2 c.–30 %
Tinplate	15 %	1 c. lb.
Beams, Girders	10 %	20–25 %
Hoop, Bands	10 %	25 %
C.I. Pipes	10 %	20 %

TABLE 107

COMPARISONS OF IRON AND STEEL TARIFFS

(A) 1877 *per cwt.*	*Pig Iron*	*Wrought Iron*	*Steel Bars or Sheets*	*Iron Rails*	*Locos*
Germany	free	free	free	free	free
Belgium	/2½	/4¾ to 1/7½	/2½ to 1/7½	1/7½	1/7½
France	/9¾	1/1½ to 1/7½	3/8 to 6/1	—	2/5¼
U.S.A.	1/3	4/8 to 7/–	10/– to 16/4	3/–	9/4

In 1879 the tendency in Europe was to relieve from artificial restrictions the importation of English iron into foreign countries.

(B) 1880 *per ton*	*Pig Iron*	*Bars*	*Iron*	*Iron Rails*	*Steel Rails*	*Sheets and Plates*	*Tinplates*	*Iron Wire*
Germany	10/–	25/10	25/5	25/5	30/10	50/10	50/–	30/10
Belgium	4/2	7/11	7/11	7/11	7/11	7/11	10 % av.	7/11
France	16/3	65/–	47/6	47/6	73/4	60/10	106/8	81/3
U.S.A.	25/–	93/4	116/8	65/–	116/8	116/8	186/8	£9 to £18
U.S.A., 1882	28/–	74/4	—	65/4	70/10	—	93/4	—

(C) 1914 and 1924	*Pig Iron, Forge and Foundry per ton*		*Tinplates Cwt.*		*Section Steel Cwt.*		*Coke Ton*	
	1914	*1924*	*1914*	*1924*	*1914*	*1924*	*1914*	*1924*
Germany	10/–	11/–	2/9	3/–	1/3	1/4½	free	free
Belgium	1/7½	/11	free	free	/5	/4	free	free
France	12/2	7/4	5/3½	4/9	2/0½	1/0½	1/–	/3½
U.S.A.	free	3/4	15 % ad. val.	4/11	10 % ad. val.	1/–	free	free

(D) 1929–1930 *per cwt.*	*Pig Iron*	*Ingots*	*Blooms, Billets*	*Bars*	*Hoop Iron*	*Tinplate*	*Wire*	*Rails*	*Scrap*	*Sheets*
Germany	1/–	—	1/6	2/6	2/8	5/–	2/6	2/6	free	—
						5/6	3/–	—	—	—
1929										
Belgium	/½	/½	/½	/½	—	/4	/1½	/1½	—	/2
France	/10	1/11	2/10	2/10	5/2	9/9	6/1	2/11	2/6	3/4
U.S.A.	/3	2/10	—	1/10	—	9/4	—	—	/2	4/3

Appendix to Chapter III

Foreign Ores (1870–193)

Ore Production in the U.S.A.

In the United States the bulk of the ores came from the Lake Superior area, which supplied over 84 per cent of the total mined during the last fifty years of the period studied. Its development was due to the highway provided by the Great Lakes.

This region produces about one-third of the world's output. The centre of production is in the neighbourhood of the Mesabi range. The total output up to 1926 was:

Range	*When Opened*	*Million Tons*
Marquette	1854	155·7
Menominee	1877	152·5
Vermillion	1884	51·5
Gogebic	1884	160·5
Mesabi	1890	747·9
	Total	1,293·1

The production in Alabama amounted to about 12 per cent of the total. Sir Lowthian Bell said in 1890 that the Birmingham, Alabama, district would dictate the world price of pig iron. The incorrectness of this prophecy indicates the importance of proximity to markets. The peak of U.S. production is predicted between 1945 and 1950.

In 1928 the United States produced 43 per cent of the world's pig iron, but she consumed only 36 per cent of the world's iron ore. This is due to the higher quality of the Lake Superior ores, which average about 50 per cent of iron against 40 per cent of iron for the average of the ore used by the remainder of the world. The United States consumed 1·80 to 1·85 tons of ore per ton of pig iron against 2·22 to 2·50 for the rest of the producing countries.

Ore Production in France

The central region of France produced most of the country's pig iron up till 1879. The eastern region produced only 3·3 per cent in

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THE CHIEF IRON ORES OF THE WORLD

Analysis %

District	*Mine*	*Type of Ore*	*Fe*	*Mn*	*SiO_2*	*CaO*	*S*	*P*	*Al_2O_3*	*Moisture*
					GREAT BRITAIN					
Yorkshire		Ordinary	30·2	0·4	12·7	5·10	0·30	0·50	11·0	—
Cleveland	Cleveland	Calcined	37–43	—	—	—	—	—	—	—
Cumberland and Lancs		Hematite								
		Ordinary	50·3	—	13	—	trace	0·009–0·013	—	5·6–6·8
		Hard	58·2	—	13	—	nil	0·008	—	4·3
Northants	Brixworth	Colite	31–38	0·3	17·4	3 1	0·12	0 71	7 0–9 0	—
Leicestershire		Middle lias	30	—	13–14	11·4	0 13	0·3–0·6	11·4	—
Oxfordshire		Middle lias	22–30	—	11–16	14	0·2–0·7	0·27–0·3	6·0–9·0	—
Lincolnshire		Lower lias	22–33	1·0	9–12	20	0·18	0·35	3 4–5·7	—
Staffordshire			35·39	—	—	—	—	0·5–1·0	—	—
					MgO					
South Wales			27–33	—	13–22	2 5–4·5	0·10–0·7	0·09–0·17	8	—
Scotland		Clayband	28	—	9·7	5·1	0·13	0·26	5·5	—
		Blackband	38	—	1·8	3·4	0·03	0·25	1·1	—
					UNITED STATES					
Lake Superior	Messabi	Hematite	56–59	0·8–1·37	5·5–6·8	0·2–0·3	0·01–0·06	0·06–0·1	2·2	—
	Vermillion	Dried Ores	64	0·01	4·9	0·2	—	0·05	2 9	—
	Gogebic	Dried Ores	60	0·7	8·1	0·37	0·034	0·06	1·9	—
	Marquette	Dried Ores	57	—	10	—	—	0·1	2·1	—
	Menominee	Dried Ores	54	0·08–0·80	7–16	1·3–2·6	0·01–0·17	0·07–0·40	1·4–4·1	—
	Upper Sea	Mahoning	63	0·3	2·8	0·14	0·01	0·04	—	—
	Adirondack	Magnetic Concentrates	61	0·09	10	1·35	0·03	—	—	—
	Cornwall		45	0·15	3·9–20	1·0–2·8	0·07	0·015	0·3–4·9	—
	Alabama	Birmingham	32–45	—	0·2–25	—	tr. to 0·5	0·25	—	—
		Clinton Ore	37	0·16	18	13·7	—	0·37	—	—

				GERMANY						
Lahn and Dill		Red Hematite	45–48	0·4	18–20	5·2	—	0·1–0·3	—	—
Siegerland		Spathic	34–40	6–9	12	—	0·26	—	—	—
Pieneilsede			26–34	4	4–8	—	—	0·9	—	—
				FRANCE						
Lorraine	Briey	Minette	26–33	4·5	4–7	9–18	—	0·9–1·9	—	—
Normandy	St. Remy		46–52	0·25	10–12	2·5–4	—	0·6–0·9	—	—
Brittany			52–54	—	—	2·0–3	—	—	—	—
Calcerous		Luxembourg	29–31	0·26	7	18–21	—	0·59–7·7	3·7–4·3	
Siliceous			32–37	0·26–1·42	14	8–11	—	0·62–0·75	—	—
				ALGERIA AND TUNIS						
Algiers	Ovenca	Red Hematite	50–66	2·3	2	4·8	0·8	0·02	—	—
Tunis	Djerissa	Red Hematite	52–59	1–1·3	1–8	1–6	0·03	0·01–0·07	—	—
			52–55	2·4	1·4	6·3	—	0·02	—	
				SWEDEN						
Kiruna		Magnetite A	67	—	2·3	0·72	—	0·02	—	—
		Magnetite D	61	—	2·0	6·0	—	1·7	—	—
Gillwara		Magnetite A	68	—	—	—	—	0·02	—	—
				SPAIN						
Bilbao	Rubic	Brown Hematite	63–55	0·06	9–11	0·6	0·03–0·04	0·01	1	—
	Vena	Red Hematite	56	—	8	—	trace	—	0·2	—

1880, 54 per cent in 1889, 69 per cent in 1906 and 85·5 per cent in 1926. The basic Bessemer process came into use in 1878, up to when the acid process had involved the import of Spanish and Algerian ores. The Briey area had been worked since 1880. Before 1914 most of the output of the Briey-Longwy basin was exported to German furnaces. The Normandy-Anjou basin is said to contain over 2,000 million tons of high grade ore. From 1913 to 1930 its output doubled, over one-half going to England and Germany.

The ores of Lorraine, though of much lower grade, were of prime importance in building up the German pre-1914 steel trade. After the war they made France the first country in Europe as regards resources, the Lorraine basin being said to contain 5,000 million tons of ore. Iron from these ores has dominated the markets of the world. In 1913 56 per cent was worked up locally and in 1926 63 per cent, the balance being exported. The equipment and organization in the area are excellent. The ore was collected in bunkers of 10 to 20 thousand tons capacity and loaded into wagons of standard gauge; grading facilities were provided.

Ore Production in Belgium

Belgium's iron and steel industry was based on the ore in the hilly district of the south, which was covered with forest and well watered. In Belgium the output of ore has been insignificant and it is practically no longer mined. In 1881–82 native ore only amounted to one-sixth of the consumption. In 1883 Belgium imported 1·82 million tons of ore from Luxembourg, averaging 2s. at the mine, while the cost at furnace was greater than for Cleveland ores. On the exhaustion of the ore deposits the industry grew upon the coalfields of Liège and Hainault. Ore was imported, chiefly from the Minette area and Luxembourg, but also from Sweden and Spain. Transport charges from Luxembourg in 1893 trebled the cost of ore at furnace. Swedish ore (via Antwerp) was used to increase the output of iron per blast furnace, but scrap later constituted a fairly large percentage of the blast furnace mixture. Nearly all Belgian works possessed mines, or shares in mines, in Minette deposits, and need purchase very little ore outside their control.

Ore Production in Germany

German iron and steel production was originally tied to the ore deposits in Upper Rhine, Upper Silesia and the Harz Mountains.

The adoption of ore smelting with coke brought a fundamental change and iron production migrated to the coal-fields. Although Germany secured possession of the Minette ore territory in 1871, it was not till after 1880—due to the development of the basic Bessemer process for which the Lorraine ore was eminently suitable—that Germany's iron ore resources became of first-rate importance. In 1903 Lorraine and Luxembourg accounted for 80 per cent of the ore production. As the transport of ore was more expensive than the transport of fuel, new blast furnaces and steel works were erected on the Lorraine ore-fields, and a large production of semi-finished products developed.

Under the Treaty of Versailles, Germany lost the Lorraine iron district, constituting 80 per cent of her resources. She became one of the poorest countries for iron ore with only 8 to 10 per cent of the ore reserves of Europe against 30 per cent prior to 1914.

The German problem became solely one of ore supply. One-half of its consumption, according to quality, and nearly two-thirds, according to iron content, was imported from France, Sweden, Algeria and Newfoundland. The situation was somewhat relieved by the increasing use of scrap which, in 1920, was almost as large as the total import of ore.

Imports into Foreign Countries

The ore imports of the United States have not often exceeded one million tons during the period under review—a small quantity in proportion to the production. Imports were not due to insufficient domestic ores being available, but for some plants near seaboard foreign ores were more cheaply available than Lake Superior ores. A partial transfer of furnaces to the coasts seems probable, however, as in the not distant future plants will require access to foreign ores.

For about twenty-five years Germany was an exporting country, but commenced to import iron ore at the beginning of the century, the quantity increasing rapidly and exceeding 11 million tons in 1913. Since 1918 imports attained the same figure, but from different sources, and exceeded the home production considerably.

French imports increased steadily till the end of last century, but after 1905 France became an exporting country, and in 1914 was exporting at the rate of over 8 million tons per annum. After 1922 the exports of France, including Lorraine, exceeded this figure and rose to nearly 12 million tons.

Belgium has always been an importing country, the annual figure

increasing to over 6 million tons before 1914. In 1920–30 this quantity was considerably exceeded.

Manganese Ore

All the iron-producing countries under review import manganese ore.

The imports into Britain increased rapidly from 1880 to over half a million tons in 1913. Her imports were larger than even those of the United States till 1916, but after the war were only about one-half the latter. The price was not far different in the two countries. In the United Kingdom it fell from £4 to £2 between 1880 and 1912, but in 1920–30 stood near the former figure.

There have been intense international struggles for the control of the manganese ore mines, the chief of which outside Russia and Brazil are under British control in West Africa and India. The world production in 1920–30 was about 2½ million tons annually. Manganese ores are smelted to form ferro-manganese, of which Britain was the chief producer up to 1925 (outside the U.S.A.). After 1924 Canada and Norway increased in importance both in production and export. Germany had no manganiferous ores and, together with France and Belgium, imported ferro-manganese or manganese ore.

Limestone

Limestone is found in most countries and as its extraction is inexpensive the question of supply raised no special difficulties. Probably one-third of the quantity raised is used in the manufacture of iron, about 8 to 9 cwt. being used for fluxing for each ton of pig iron made.

From this average figure the quantity varies widely according to the ore used (the burden make-up), the type of iron being made and so on. Where the ore is of a self-fluxing character, as in Lorraine and Lincolnshire, the quantity used is naturally very small. Sir Lowthian Bell recorded that the quantity varied from 5 to 15 cwt. In 1883 he gave the following comparison of prices in various countries:

England	3/– to 4/–	This country was evidently paying more per ton than the Continent. In the U.S.A. transport was evidently raising the price at important consumption centres.
Germany	2/– to 3/6	
France	1/3 to 2/3	
Belgium	1/2 to 2/6	
U.S.A.: Pittsburgh	6/9	
U.S.A.: Alabama	2/6	

From 1891 to 1913 the average price of limestone was 3s. 6d. to 4s. 6d., showing a slightly upward tendency over the period. In this country the percentage of consumption and sources of supply in 1918 were:

	Consumption (per cent of total)	Supply
East Coast	40	Weardale
Midlands	22	Buxton and North Staffs
West Coast	15	Local
Scotland	14	North Wales, York
South Wales	9	South Wales

The average consumption in both the U.S.A. and the United Kingdom has fallen since 1918–20 from 9·7 cwt. to 7·25 cwt. per ton in 1930. Open-hearth slag is now being introduced to reduce the limestone used.

Limestone is not a major factor in production and cannot be looked upon as a cause of any outstanding differences in the cost of pig iron.

Notes on Foreign Coke Production

U.S.A.

In the U.S.A. the percentage of by-product coke produced in plants associated with iron furnaces increased from 73 per cent in 1913 to 80 per cent in 1928, but the use of coke other than in the blast furnace also increased. The coking coal used annually in coke ovens amounted to about 80 million tons, about 20 per cent being wasted by the use of beehive ovens. In 1926 the potential capacity of by-product ovens was 50·5 million tons, production 4·5 millions, and in 1928 58·5 million tons, and 52·8 millions respectively. In this year American coke practice was said not to be as good as German practice but the units were larger. The average size attached to steel works was about 3,000 tons per day. The uniformity of the coke produced could not be attained under British conditions.

By-product ovens can profitably distil tar and extract creosote before burning the residues, but continuous operation is necessary. The economic minimum for a plant is half a million cubic feet of gas per month. The cost of coal for by-product ovens was sometimes above the selling price of the coke produced. Foundry coke amounted to 5½ to 6 per cent of the total production.

France

The supply of fuel has always been a difficult problem in France as output was below consumption, whilst other iron-producing countries had fuel in relative abundance.

In 1913 the Departments of Nord and Pas de Calais were responsible for 75 per cent of the coke production, but the total deficit was 3 million tons. After the return of Alsace-Lorraine in 1918 this yearly deficit was increased to 7 million tons.

Germany

Seventy per cent or more of the coke was made in Westphalia. In 1909 82 per cent of the coke produced was made in by-product furnaces. There were 10,000 non-recovery ovens in 1900 and only 218 in 1918. In that year 24,000 by-product ovens produced 34 million tons (4 to 5 tons per oven per day). New Koppers ovens, in batteries of 50 to 65 ovens, yielded 11 tons of coke per oven every 24 hours.

Imports of German coke into Great Britain demonstrated the uniformity of coke from a whole district (Westphalia) obtained by suitable blending of coals.

The Vereinigte Stahlwerke in the first 2½ years of its existence erected 894 coke ovens with a capacity of 5 million tons (5,000 per oven), in addition to the 4,923 previous ovens of 1,800 tons per annum. Some ovens could produce 10,000 tons per annum.

The output per worker has increased threefold over the sixty years studied.

The German cokeries are near to the coal-mines and iron and steel works, and the German coal syndicate is controlled by the metallurgists.

Belgium

Belgium is poor in ore and coal. In 1902 only 166,000 tons of coal was produced, equal to one-twentieth of the consumption.

Coking coal came from the south and east parts of the central area, and from the Mons area in the south.

Bituminous coal was imported from Great Britain and Germany. The coal industry in the Campine may partially free Belgium from foreign dependence. In 1924 more than one-seventh of the coke consumed was imported. In 1929 consumption in blast furnaces equalled 3·80 million tons, of which rather more than half was from home coal.

Considerable progress was made in the operation of coke ovens and by the scientific blending of coals the quality of coke was improved. In 1929 all the ovens were of the by-product recovery type. The new Simplex ovens had a coking time of sixteen hours but the newer narrow ones gave smaller coke. For charging the coke ovens and drawing coke into skips one man per shift handled 10 tons of coal.

There was a Belgian coke and coking coal syndicate, presided over by Baron Copée, including 27 companies with an annual output of 5 million tons. Great expectations were held of the results to be obtained from this rationalization.

Historical Review of Coke Ovens and Coke Production

Beehive coke ovens were first used in Great Britain in 1826 at the Duke of Norfolk's colliery at Sheffield, and in that year modern blast furnace practice may be said to have begun.

By 1850 beehive ovens had been practically perfected in England. In that year continuous coal-washing methods were introduced, the coking time being about 72 hours, the coke in the beehive ovens being quenched *in situ*. An excellent coke was made by the slow heating in beehive ovens, but coking in piles was still carried on.

On the Continent the leaner types of coal did not yield a strong coke in beehive ovens, and in 1852 the Sinet or Belgian rectangular or chamber oven was introduced with 2½ tons of coal coked in 24 to 48 hours. The François-Rexroth ovens, capable of coking a 3-ton charge in 48 hours, were the earliest coke ovens using horizontal and vertical flues.

From this period the chief feature has been the increase in production of by-product coke. In England the prejudice against the character of by-product coke died hard, and even in 1930 beehive coke was preferred by some foundrymen.

The invention of chamber ovens with heat recuperation and by-product recovery for the production of metallurgical coke was largely the result of Belgian and German research. In 1861 Copée introduced a vertical flue non-recovery oven which coked 3 tons of coal in 24 hours. In 1862 the Pernolet oven was constructed, using a comparatively thin layer of coke and with a coking time of about 70 hours. Recovery of by-products was attempted.

In 1864, when Bell Brothers experimented with the Pernolet oven in this country, there were 400 ovens of this type in France.

In 1862 the Carves Company constructed ovens with side flues and Siebel admitted gas to the side flues.

In 1867 Copée ovens were introduced into Germany by the Otto Company. They were of non-recovery type.

The introduction of the first by-product recovery oven into the countries under review may be taken as follows:

France	Carves	1878
Germany	Bussener	1881
Belgium	Semet-Solvay	1882
Great Britain	Simon-Carves	1882
United States	Semet-Solvay	1892

In 1870 all coke made in this country was beehive coke, but the Wigan Coal Company, as well as Bell Bros., made trials in 1870 of the Pernolet recovery oven. The coke was, however, of unsatisfactory quality.

In 1873, when the first Copée battery was erected at Chapeltown, Yorkshire, there were 2,000 ovens of this type in Belgium and Germany. In 1874 the height and width were increased and the coking time became 48 hours.

In 1880, when most of the coke used in iron smelting in this country was made in beehive ovens, there were 3,000 Otto-Copée ovens in the Ruhr district, and only 500 of the beehive type. This was because the slow heating did not agglutinate the coals enough to make a good coke. Otto was experimenting with recovery ovens and Hoffman attempted to apply the regenerative principle to coke ovens.

In 1881 a battery of Simon-Carves ovens was erected at Gelsenkirchen, each oven coking 5½ tons of coal in 60 hours. In this year a recovery battery was tried at Pease and Partners' works in Durham. The coking time was 60 to 72 hours, but the coke was not of satisfactory quality. In 1882 Semet added separate sets of flues and a dividing wall to the Carves oven, and must be credited with the "narrow chamber." Bell's experiments on Simon-Carves ovens took place in the same year. He found that 2¼ cwt. more coke was required than of beehive coke per ton of pig iron made. His unfavourable view retarded by-product coke oven development in this country. It should be recorded that Samuelson's experiments at the same date did not confirm Bell's results, but the latter's views were more generally accepted.

In 1883 Simon added a recuperator to the Simon-Carves oven, and subsequently little further development took place in England.

In 1884 Semet-Solvay ovens were erected at Nantwich with a charge of 4 tons which was coked in 24 hours. This type of oven was most used in this country up to the end of the century, there being over 400 in the year 1900.

Between 1884 and 1893 the Otto-Hoffman oven was the most popular in Germany, $6\frac{1}{4}$ tons being coked in 36 hours. In 1896 the Otto-Hilgenstock waste heat type of oven was introduced, and by 1900 $7\frac{1}{2}$ ton charges were being worked in 30 hours. In 1898 Otto ovens were erected at the works of Sir B. Samuelson and Company, Middlesbrough, the coking time being 29 hours and the coke suitable for blast furnace practice. Otto-Hilgenstock ovens were erected at Newport Iron Works, Durham. By 1900 there were 6,600 Copée-Otto ovens in the Ruhr district and the compression of poorer coking coals had been adopted.

In 1902 Koppers devised the addition of dampers at the top of the flues in the Otto-Hoffman oven. In England the Carves oven was modified in 1903 so that a 10-ton charge could be charged into each oven. After Bell Bros. had favourably reported in 1904 on the Hussener ovens, a more rapid development of by-product ovens occurred, but in 1905 only 51 out of 251 plants worked with recovery of by-products.

In 1905 regenerators were added to the Otto-Hilgenstock oven, and in 1906 a regenerative type of Simon-Carves oven was introduced. In 1909 the regenerative battery was introduced into England with a coking time of 28 hours for dry coal and 31 to 33 hours for wet coal. In 1911 benzol recovery became general.

As regards mechanical equipment, sloping benches, coke conveyers and mechanical coal charges had been introduced by this time.

Most of the development in design of later ovens has been in dimensions, the most notable advances being due to the Americans. In 1906 the size of ovens in Europe was stabilized at $7\frac{1}{2}$ to 8 tons capacity with a coking time of about 28 hours for dry coal. The average throughput of coal per oven per day was much the same in all countries before 1914, having gradually risen as the size of the oven was increased to take a 10-ton charge of wet coal, the coking time being about 32 hours, and the daily coke production about 5 tons per oven.

Considerable development had occurred in America. In 1904 the average output was 6 tons. The ovens were narrowed and the height increased, and the capacity raised to 15 tons in 1914. In this

year, when the five horizontal flue Semet-Solvay oven was adopted in England, the six flue regenerative type was introduced in the United States. By the use of narrow ovens and silica bricks, which have a higher thermal conductivity and load bearing capacity, enabling higher flue temperatures to be attained, the coking time was reduced to half that in Europe. The discharge time was reduced from 6 minutes to 45 seconds.

In 1915, in the United States, the by-product recovery oven won its fight as regards the quality of coke produced and as regards return on investment. It was not until 1919, however, that the by-product coke production exceeded the beehive coke production, and the beehive oven, with its low capital cost and simplicity in use, came to be regarded as a standby for peak loads.

It will be seen that other factors than economic ones have affected the development of by-product ovens, otherwise the U.S.A. could be accused of as much conservatism as Britain.

After 1918 the development in oven capacity continued up to 20 tons, and American practice was subsequently adopted in Germany and other Continental countries, and a start made in Britain. In general the capacity was raised to 16 to 25 tons of coal per day. In coking plant Britain lagged behind practice on the Continent, standing, after 1918, roughly where the Continent stood before 1914.

In 1923, when the daily output in both British and German practice was 4 to 5 tons of coke per day, the American average was two to three times this, say 11 to 14 tons per day. Germany, however, was rapidly catching up, one-third of her plant in 1926 having been rebuilt on up-to-date lines, and the average labour cost being 10d. to 11d. per ton.

In the United States only two firms shared coke-oven construction work, whilst in England there were about a dozen firms competing for about one-third of the work.

In 1924 Wilputte ovens were started up at Consett, and excellent coking operations were performed in 15¼ hours.

In 1925 Mott wrote (*Fuel in Science and Industry*) that England had shown less initiative than any other large-scale producing country since the War, and in 1930 this remained an outstanding fact. One of the reasons for the slow advance in Britain was the number of small concerns, the intervention of the war and unsettled conditions. Owing to the depression in the pig iron industry coking plants were allowed to go out of repair or become obsolete.

In 1926 it was stated that the large majority of plants was obsolete from a money-making point of view, owing to their high labour costs, which averaged 5s. per ton. The high labour cost was attributed not to high wages, but to the small plants. The rebuilding of these inefficient plants was said to be necessary as the iron and steel makers could not afford to pay this additional 4s. per ton compared with Germany, and might have to import coke.

In 1928 the oldest type of oven in Britain produced 12 tons a week, and the ordinary by-product oven produced up to 50 tons per week.

In the U.S.A. the tendency was to produce in large units near the iron and steel works, with as much labour-saving machinery as possible. In Great Britain the slow adoption of the newest types of oven and concentration in large units was due to the high capital cost and high depreciation cost per ton of output.

Centralized coking might have resulted in a reduction of cost of several shillings per ton, but the smaller iron and steel units in Britain were opposed to this, and the higher railway rates were also an adverse factor. The problem of the disposal of surplus coke-oven gas was being solved by utilization in town gas systems.

The more recent types of oven included the Koppers taper oven, the Becker oven, the Otto compound oven and the Piette oven. Piette regenerative ovens had been erected at the Stanton Iron Works. Refinements could, however, be carried too far. For example, whilst there was a saving in capital cost from hot-oven firing and a shorter coking period, the output of by-products was smaller.

It will be seen that the development of the modern type of coke oven dates from the beginning of this century, but during the last decade of the period under review improvements had been made in direct processes of recovery of the by-products, so that a modern coke-oven plant became a chemical works. British engineers could claim improvements in auxiliary machinery, such as quenching machines and ammonia scrubbers, and many advances had been made in by-product recovery plants, tar extraction and desulphurization.

Coke Quality

Clean and uniform coke is probably the primary requirement of iron and steel works. Variable coke means variable pig iron, which introduces variations in the open-hearth furnace, and causes difficulties in the economic management of blast furnaces.

The essentials of a good blast furnace coke are:

(1) Low content of ash, sulphur moisture and perhaps phosphorus. Good blast furnace coke contains under 9 per cent ash and 4 per cent water, and good foundry coke under 8 per cent ash and 4 per cent water. An average ash content is 8·5 to 12 5 per cent. About 10 per cent of the coke is required to fuse its own ash. The elimination of sulphur (0 8 to 1·0 per cent) requires about 150 lb of coke per ton of pig iron.
(2) High strength to support the weight of 65 to 70 feet or more of superincumbent material.
(3) Porosity for easy penetration of ascending gases and rapid consumption at the tuyère level.
(4) Resistance to the attack of carbon dioxide, as formation of carbon monoxide means a waste of fuel (Reactivity in CO_2).
(5) Hardness or resistance to impact.
(6) Resistance to abrasion.
(7) Uniformity in size.
(8) Freedom from breeze.

The tests for determining physical quality include crushing test, shatter test, tumbler test, combustibility test and reactivity test. The poorest coke mechanically is generally the worst chemically. Improved physical character increases the rate at which the blast furnace can be driven. As showing the effect of size: Westphalian coke of 6-inch cubes, imported during the 1926 strike, resulted, on the north-east coast, in the saving of 1½ cwt. of coke per ton of pig iron.

Methods for improving coke quality include the following:

(1) Adequate cleaning of coal.
(2) Blending.
(3) Fine grinding.
(4) Optimum methods of carbonization.
(5) Suitable methods of quenching.
(6) Adequate screening and proper handling to reduce breeze.

1. Cleaner coal involves separation and selection, and the production of coke with only 8 to 8·5 per cent ash. By this process the output of a blast furnace was increased from 700 tons per week to 950 or 1,100 tons per week. Coke washing removes ash and sulphur and gives better physical properties.

The following figures were given by Lessing (*Journal of Institute of Fuel*, 1928):

	Cwt. per ton of Pig Iron		
	Old Washing	*Modern Washing*	*Clean Coal Plant*
Coke required	23·50	21·51	19·62
Limestone	4·40	2·92	1·61
Slag	6·00	3·96	2·04

2. Blending of coal in Yorkshire reduced the carbonization period from 30 to 18 hours. Blending is intensely practised on the Continent and central blending stations are suggested in this country. The erection of large silos as in German practice is recommended.

3. Fine grinding prior to carbonization reduces the fuel consumption in the blast furnace.

4. Coke made in the narrower and quicker modern ovens is more economical in blast furnace use than coke made in the wider and slower coking ovens, and has greater combustibility.

The advantages of the narrow coke oven are:

(1) Increased rate of coking.
(2) Greater uniformity and superiority in the nature of the coke.
(3) Increased output and quality.

In 1924 there were no narrow type ovens in Britain.

The coking period in by-product ovens in Britain was 26 to 36 hours, with 30 hours as a fair average; when in the narrow type ovens with 14 inch top width the period was 10 to 12 hours. At Bahnschacht, with ovens of this top width, 16 tons of coke per oven was produced every 24 hours.

The limit in high-speed operations has not been reached, but in spite of the success of the narrow oven, the high operating costs demanded a high output and the decreased capacity per oven charge limited the tendency to reduce the width of the chambers.

The following are practical figures showing the effect of oven width:

Width *Inches*	*Operating Time* *Hours*	*Charge* *Tons*	*Throughput* *Tons per day*
20·8	32·1	10	7·4
13·7	14·3	6·6	11·05

5. The Sulzer method of dry quenching of coke gave a considerable economy as it increased the thermal efficiency of the coking process. The limiting factor in high-speed operation was the rate at which coke could be loaded or conveyed from the coke-oven plant. The fuel saved at Home Court by this method was said to be 100 kg. (220 lb.) per ton of pig iron.

6. The effect of screening out the breeze is to raise the quantity of iron made per week in a given furnace. The usefulness of British cokes, as measured by the quantity of breeze, placed them in the following order.

Durham and South Wales
Cumberland
South Yorkshire
Derbyshire

Durham coal fields probably contained the finest coking coals in the world, but there was said to be little, if any, difference in the metallurgical coke used in England, the U.S.A. and Germany.

The average quality of the coke used in Luxembourg and Belgium was better than that in the United Kingdom, the regularity arising from the large centralized coking plants. In this country the regularity of physical conditions and analysis was not assured. Improvements occurred, however, in the following directions:

(1) Coke screening and culling plants.
(2) Increased production in by-product ovens.
(3) Greater attention to coal blending.
(4) The handling of fines at the washery.
(5) The formation of Coke Research Committees.

The best features in Continental practice were being absorbed, more especially the adoption of large-scale high-speed operations, involving the minimum of labour requirements. Attention was being given to the recovery of the sensible heat in coke. In addition to by-product recovery the disposal of surplus gas was being dealt with. The National Fuel and Power Committee of the Board of Trade investigated the Area Gas Supply System, and the scheme was initiated in the Sheffield area.

Number of Coke Ovens and Average Output

In 1930 the total number of coke ovens was greatest in the U.S.A., followed by Germany, Great Britain, France and Belgium. The preponderance of the U.S.A. was due to the vast number of beehive ovens. The total number of ovens increased generally up to 1914. Since 1918 they decreased in all countries due, of course, to beehives passing out of service. The relatively small total number of ovens in France and Belgium was, of course, due to the early development of chamber ovens. They were practically all of by-product recovery type.

The general average output per oven, which will be briefly compared, increased slowly in all countries before 1913, but rapidly afterwards. In the U.S.A. the number of beehives naturally caused the average to be low. The average in Great Britain was higher than in U.S.A. It was highest of all in Germany, but Belgium followed closely in this respect, having progressed rapidly since the beginning of the century. The production per oven increased rapidly in France towards the end of the period, and approached

that of Germany and Belgium. As far as can be ascertained, the output per beehive oven in Great Britain was higher than in America.

The construction of by-product ovens started on an appreciable scale in the last years of the 19th century. They increased rapidly in Germany, where they were in the greatest number. The U.S.A. and Great Britain came next, with approximately the same number up to 1918, since when the number of by-product ovens increased steadily in the former but fell somewhat in the latter. In France the number increased rapidly after 1919.

The average output of by-product ovens was highest in the United States, being roughly twice as great as in Germany and this country; in this particular, Britain was not far behind the Continent. In Great Britain over one-third of the 10,000 by-product ovens were over twenty-five years old, and 8,000 over twelve years old. Modern ovens charged 8 to 16 tons of coal per oven every 12 to 22 hours with a throughput of 16 to 25 tons per day. The new coking plant developments in Germany included ovens charging 28 to 29 tons of wet coal, with a coking period of 18 hours, or, if pre-drying of the coal was resorted to, an output per oven per day of 36 tons.

The rather unfavourable position in Britain was probably also connected with a smaller average size of coke-oven battery, as illustrated by the fact that in 1927 the cost per ton from a battery handling 1,300 tons of coal per day was 6s. 1d., compared with 11s. 11d. per ton for a battery handling 270 tons per day (R. Ray, *Transactions Institute of Fuel*).

The Change-over from Beehive to By-product Metallurgical Coke

Whilst coke was made in chamber non-recovery ovens in Belgium after 1850, and in France after 1860, the change-over from bulk production in beehive to bulk production in by-product ovens occurred first in Germany, where it was largely completed by the first years of this century, then in France, Great Britain, between 1900 and 1920—the change-over being considerably hastened by the war—and then in the United States, where it was also mainly completed during the war years. In both these countries over 90 per cent of the coke is now produced in by-product ovens. The greater use of by-product ovens in Continental countries gave them fairly cheap coke supplies.

Coal Resources

The Toronto Congress in 1913 estimated the reserves of coal as follows:

U.S.A.	3,838,000 million tons
United Kingdom	189,500 " "
Germany	423,000 " "
France	17,500 " "
Belgium	11,000 " "
The World	7,397,500 " "

The chief features are the large resources of the United States and the relative poverty of France and Belgium in this respect. Europe has 15 to 20 per cent of the world's reserves, Germany being first and Great Britain second. Up to nearly the end of the nineteenth century Britain was the greatest coal producer in the world. The production of the United Kingdom was over 50 per cent of the total in 1870, but fell to 21·8 per cent in 1913, German production following closely that of Britain. In the same period production in the U.S.A. increased from 14 per cent to 38 per cent.

Up to 1913 the trend curve sloped upwards faster in the United States than in Germany, and in Germany than in the United Kingdom, the average increase per year being:

U.S.A.	18 million tons
Germany	6 " "
United Kingdom	5 " "

In the U.S.A. production increased up to 1918, and then dropped. It has surpassed the 1913 level since 1923. In Germany and the United Kingdom production has remained lower than in 1913. Although on a smaller scale, France and Belgium exceeded their pre-war production after 1924. The deficit of coal produced in France was 50 per cent in 1913, and thus she gained little by the war.

In Great Britain in general many of the best seams have been worked out, and, with the exception of the newer collieries in the South Yorkshire coal-field, coal has become more inaccessible. Without improvement in mining methods the cost of winning coal must undoubtedly increase, but methods of mining have improved in respect of mechanical equipment and the welfare of the workers. The improvements in mechanical means cover a wide field, predominantly the provision of conveyers, drills and the application of explosives on a more extensive scale. Development of electrical power for this purpose is almost entirely confined to the 20th century.

At the coal face there have been marked advances in production by power machinery, in the utilization of low-grade fuels, and in the improvement of the efficiency and safety of the winding gear. It is doubtful, however, whether improvements in coal winning have progressed as fast in Britain as in some competitive countries. Comparison of the coal production per person employed per annum in the five countries indicates that the U.S.A. is most efficient in this respect whilst in 1910 the United Kingdom lost second place to Germany.

Appendix to Chapter IV

Pig Iron

Technical Factors Concerned in Improving Blast Furnace Output

1. Richer ore mixtures, sintering, sizing and grading, uniform ore analysis, the use of scrap, give increasing output.
2. Better coke, i.e. more uniform, stronger and more porous, giving more complete combustion, less fuel dust.
3. Greater volume of air, higher blast pressure and temperature, distribution and control of blast.
4. Improved methods of charging, introducing coarse separate from fines, more uniform distribution of stock in the furnace, better size distribution of raw materials. Maintenance of regular level.
5. Improved stoves and linings.
6. Improved bells and hoppers with no escape of gas. Steeper bells, with a larger clearance and quicker drop. The double charging bell has improved the economy in the furnace in that it gives a better disposition of the charge.
7. Larger hearths and lower boshes. Larger stock lines give a reduction in gas velocity. In large furnaces there is a considerable decrease of hearth radiation per unit of output. Although furnace and hearth area cannot safely be correlated, a furnace of 10-foot hearth driving at the rate of 150 lb. of iron per sq. ft. of hearth requires 320 lb. of coke per ton of pig iron more than a 20-foot hearth under similar conditions.
8. Higher driving rates. High furnace outputs and low fuel consumption generally go together.
9. More power from waste gases. If burned under boilers enough power is generated to operate blowing engines, hoisting machinery, etc. Use of waste gases to reheat the blast. Underfiring coke ovens.

10. Improved dust catchers, gas washers and dryers, mud guns, stock line recorders, tuyères, turbo blowers, charging control.
11. Improved loading and charging. Elimination of laborious hand labour.
12. Smoother operation with more recording instruments.
13. Further study of fundamental reactions in furnaces.

TABLE 109

PIG IRON PRODUCTION PER MAN EMPLOYED

Country	*Year*	*Pig Iron Production (Thou. gross tons)*	*Average Number of Wage Earners*	*Average Annual Tonnage of Pig Iron per Wage Earner*
United Kingdom	1901	7,928	12,742	622
	1906	10,183	30,000	339
	1911	9,526	21,698	439
	1920	8,034	40,250	199
	1921	2,616	20,000 approx.	130
	1922	4,902	21,756	226
	1923	7,440	29,749	250
	1924	7,307	28,553	256
	1925	6,260	23,334	208
	1926	2,458	14,900	165
	1927	7,292	20,000	302
	1928	6,610	21,986	300
	1929	7,589	—	—
	1930	6,192	17,500	354
United States	1904	16,624	35,078	474
	1909	25,652	38,429	668
	1914	23,270	29,356	793
	1919	30,543	41,660	733
	1921	16,618	18,698	889
	1923	40,162	36,712	1,094
	1925	36,700	29,100	1,260
	1926	39,372		—
	1927	36,565	27,958	1,305
	1928	38,155	—	—
	1929	42,613	24,960	1,700
	1930	31,752	—	—
	1931	18,426	13,572	1,350
France	1913	5,217	17,800*	305
	1919	2,412	15,194	158
	1920	3,433	20,755	165

* Comité des Forges.

TABLE 109—*continued*

Country	*Year*	*Pig Iron Production (Thou. gross tons)*	*Average Number of Wage Earners*		*Average Annual Tonnage of Pig Iron per Wage Earner*	
France—*continued*	1921	3,360	19,871		169	
	1922	5,228	16,099		324	
	1923	5,431	26,763*	21,888†	203*	248†
	1924	7,693	17,807	22,200	432	346
	1925	8,494	22,775	22,775	372	372
	1926	9,431	20,318	22,300	455	414
	1927	9,273	—		—	
	1928	9,980	—		—	
	1929	10,363	—		—	
	1930	10,035	—		—	
	1931	—	—		—	
	1932	—	—		—	
	1933	6,324	6,956		910	
Belgium	1913	2,485	5,289		470	
	1920	1,116	4,319		259	
	1922	1,613	4,479		360	
	1923	2,148	4,935		436	
	1924	2,844	5,322		535	
	1925	2,541	5,930		429	
	1926	3,368	6,152		547	
	1927	3,709	7,065		525	
	1928	3,905	7,104		550	
	1929	4,109	7,704		530	
	1930	3,474	7,144		485	
Luxembourg	1913	2,548	5,233		487	
	1920	693	4,007		173	
	1921	970	3,237		300	
	1922	1,679	4,004		420	
	1923	1,407	4,181		335	
	1924	2,157	5,155		418	
	1925	2,363	6,222		381	
	1926	2,559	6,650		391	
	1927	2,732	7,327		374	
	1928	3,770	7,236		382	
	1929	2,906	7,463		390	
	1930	2,472	6,364		390	
Germany	1907	11,390	40,933		277	
	1908	10,505	39,562		267	
	1909	11,092	38,212		288	

* Comité des Forges
† N.F.I.S.M.

TABLE 109—*continued*

Country	*Year*	*Pig Iron Production (Thou. gross tons)*	*Average Number of Wage Earners*	*Average Annual Tonnage of Pig Iron per Wage Earner*
Germany—*cont.*	1910	13,111	41,091	314
	1911	13,845	42,742	324
	1912	15,600	39,327	397
	1913	16,761	41,908	399
	1914	12,480	34,047	305
	1915	10,189	26,706	379
	1916	11,327	29,710	380
	1917	11,600	35,724	325
	1918	10,679	28,706	371
	1919	6,284	33,879	183
	1920	7,044	36,745	191
	1921	7,845	37,125	210
	1922	9,395	36,979	274
	1923	4,936	33,463	147
	1924	7,812	24,371	320
	1925	10,177	23,266	435
	1926	9,643	—	—
	1927	13,102	—	—
	1928	11,804	—	—
	1929	13,400	—	—
	1930	9,694	16,667	584

Gross Productivity of Pig Iron Workers

The difficulty in comparing actual productivity lies in insufficient records of the actual working hours in the different countries. In Britain data on working hours were collected for the censuses of production and average figures for the industry were given.

In the *Abstracts of Labour Statistics* figures are given for the average number of shifts per man per week, but these refer to the whole industry, including iron and steel together, and, therefore, constitute a complex index which does not accurately apply to blast furnaces alone. It appears difficult, if not impossible, to draw up a table of the real working day in the industry. In a general way, however, the fundamental change of the substitution of the three-shift for the two-shift system may be said to have taken place between 1914 and 1919.

In the United States, prior to 1924, the blast furnaces were largely on a 12-hour day, but the 8-hour day had been largely adopted by 1924, the average hours for the industry being about 56 per week. In Germany in 1923 the 8-hour day was prolonged by order, but

in 1925 it was again made compulsory. In France and in Belgium the 8-hour day was provided for by law and by regulations. For the last years of the production tables, therefore, neglecting considerations of short time, part time and overtime in the different countries, the data may perhaps be considered roughly to indicate the productivity of the workers in the different countries.

The following productivity data are obtained from Census of Production figures:

Year	*Production of Pig Iron*	*Number of Workers*	*Average Hours per Week*	*Productivity Index*
1906	10,183,000	30,000	55·2	100
1924	7,307,000	28,553	49·9	84
1930	6,192,000	18,083	50	112

The figures indicate that the average productivity of blast furnace workers had not increased. This is in general agreement with the following statement from a firm in North Wales.

> "All we can say is that the men employed here in approximately the same number as pre-war do the same amount of work."

If we assume that, owing to the general operation of the 8-hour day shift since 1919 the average working hours have been approximately 50 per week, the table may be extended as follows:

Year	*Index*	*Year*	*Index*
1906	100	1925	88
1920	65	1926	54
1921	43	1927	99
1922	74	1928	98
1923	82	1929	—
1924	84	1930	112

This table, apart from Census of Production years, excludes all considerations of the short time in years of depression and overtime in prosperous years, which would, of course, to some extent, explain the low figure for 1921. If from 1920 the figures were corrected for the average number of shifts worked in the iron and steel industry per week, they would not be greatly altered, but, as a matter of fact, the blast furnaces are not so sensitive to depression as steel works and rolling mills. The figures show that productivity increased after the European War, but the post-war productivity was not greater than that at the beginning of the century which, even if the numbers of employees given in the population censuses of 1901 and 1911 are badly out, they only tend to confirm.

Data which have been furnished by individual firms, and are given below, are not in some cases at variance with this, that is, if a diminution of only 10 per cent in working hours per week is assumed the output per man per hour had not increased. In some cases, however, unless the working time has not diminished as much as this there is an increase in productivity.

TABLE 110

PRODUCTION PER MAN PER WEEK IN TONS

Locality of Firm	*Pre-1914*		*Post-1918*		*Increase per cent*
Wales	8·47	(1913)	8·10	(1927)	4·4*
Lincolnshire	17·42	(1914)	18·24	(1927)	4·7
Scotland	6·94	(1913)	7·56	(1927)	9·0
Sheffield	11·9	(1912)			
District	11·4	(1914)	12·9	(1927)	10·7
Cumberland	7·8	(1913)	8·9	(1927)	14·0
Staffordshire	4·42	(1914)	5·34	(1927)	20·8
Cumberland	7·55	(1913)	10·19	(1927)	35·0
,,	8·8	(1913)	11·88	(1927)	35·0
Yorkshire	7·0	(1907)	9·6	(1927)	37·0
,,	7·0	(1908)			
Wales	Not working		18·38	(1927)	—
Lancs.	11·3		16·95		50

* Decrease

The productivity of blast furnace workers in the United States over a period of thirty years, as determined by the Bureau of Labour Statistics in terms of an index number, is shown in the following table. These figures are based on a co-ordination of Trade Association data on production, Census of Manufacture data, the employment figures of the Bureau and also the Survey of Current Business by the Department of Commerce. The index appears to relate to data covering the industry and not to have been derived by the method of sampling.

INDEX OF PRODUCTIVITY OF BLAST FURNACE WORKERS IN THE U.S.A.

1899	43·5	1921	110·0
1904	58·5	1923	154·0
1909	80·0	1925	187·0
1914	100·0	1927	195·0
1919	96·0	1929	252·0

It will be seen that there was undoubtedly an increase in productivity from the beginning of the century up to about 1914–15, followed by a depression and a rapid increase from 1923 onwards.

Appendix to Chapter V

TABLE III

PUDDLED BAR PRODUCTION (000 TONS)

Year	*Britain** *Puddled Bar*	*France Puddled Bar*	*Germany†* *Schweiss Stabeisen*	*Belgium‡* *Puddled Bar*	*U.S.A.§* *Finished Rolled*	*World*
1870	2,600	914	932	491	1,170	6,920
1871	—	758	1,020	457	1,280	—
1872	2,500	1,013	1,160	502	1,650	—
1873	—	893	1,180	480	1,620	—
1874	—	856	1,270	510	1,520	—
1875	2,220	870	1,080	436	1,470	6,625
1876	—	837	1,010	399	1,330	—
1877	—	884	860	378	1,320	—
1878	—	843	990	405	1,390	—
1879	—	857	1,016	410	1,850	—
1880	2,721	966	1,110	493	2,120	7,650
1881	2,681	1,026	1,360	479	2,340	—
1882	2,841	1,073	1,490	500	2,220	9,680
1883	2,730	979	1,450	478	2,050	—
1884	2,237	877	1,490	471	1,750	—
1885	1,911	782	1,400	474	1,660	7,120
1886	1,616	767	1,360	470	2,030	—
1887	1,701	772	1,550	532	2,300	6,340
1888	2,031	817	1,580	548	2,140	6,840
1889	2,253	809	1,650	620	2,350	8,850
1890	1,923	825	1,490	577	2,560	8,560
1891	1,733	833	1,490	—	—	—
1892	1,560	829	1,380	—	—	—
1893	1,363	808	1,110	—	—	—
1894	1,339	786	—	—	—	—
1895	1,148	757	920	420	2,200	6,470
1896	1,214	829	—	—	—	—
1897	1,238	784	1,110	475	—	—
1898	1,115	766	—	—	—	—
1899	1,201	834	—	—	—	—
1900	1,162	708	950	360	2,200	6,690
1901	974	567	900	406	—	4,600
1902	998	640	820	480	1,920	4,580
1903	950	590	—	401	—	—
1904	936	662	—	435	—	—

* B.F.I.S.M.

† Verein deutsche Eisenhüttenleute.

‡ Finished iron was several times the above quantities.

§ Finished rolled iron.

TABLE III—*continued*

Year	*Britain** *Puddled Bar*	*France Puddled Bar*	*Germany†* *Schweiss Stabeisen*	*Belgium‡* *Puddled Bar*	*U.S.A.§* *Finished Rolled*	*World*
905	938	670	830	280	2,100	[illegible]
906	1,010	748	—	—	—	—
907	975	580	—	—	—	—
908	1,168	560	—	—	—	—
909	1,129	558	—	—	—	—
910	1,118	526	350	160	1,780	4,700
911	1,191	518	—	—	—	—
912	1,326	575	—	—	—	—
913	1,206	406	210	147	1,720	[illegible]
914	1,210	—	—	68	1,170	—
915	942	—	—	12	1,290	—
916	960	—	—	35	1,820	—
917	816	—	—	11	1,870	—
918	646	—	—	12	—	—
919	540	103	—	23	—	—
920	588	144	75	34	1,410	2,300
921	218	117	—	40	570	1,050
922	219	150	—	24	950	1,400
923	332	120	—	30	1,020	1,650
924	308	110	—	25	740	1,400
925	209	100	50	15	770	1,200
926	110	90	25	21	700	1,100
927	190	—	—	14	560	1,000
928	170	90	—	—	—	990
929	160	100	10	12	475	980
930	112	—	—	—	316	—

* B.I.F.S.M.
† Verein deutsche Eisenhuttenleute.
‡ Finished iron was several times the above quantities.
§ Finished rolled iron.

APPENDIX VI

Appendix to Chapter VI

xport Constituents

In the following lists are given the principal components of the xports of Britain, Germany, France, Belgium and the U.S.A.

TABLE 112

EXPORT COMPONENTS

GREAT BRITAIN (000 TONS)

Year	Rails	Tinplates	Galv. Sheets	Bars, Angles, Shapes	Cast Pipes and Fittings	Tubes and Fittings	Sheets Under $\frac{1}{8}$ in.
1893	460	389	170	—	—	—	—
1900	375	270	250	145	—	—	—
1905	550	355	405	150	120	95	60
1910	485	482	600	225	190	170	75
1913	507	495	668	250	235	165	68
1920	130	353	410	365	100	126	140
1924	175	556	650	285	—	—	260
1929	326	580	710	315	136	317	280
1930	240	508	431	215	116	230	185

GERMANY (000 TONS)

Year	Merchant Iron and Steel	Rails	Sheets and Plates	Ingots, Blooms, Billets	Wire	Pig Iron	Wrought Tubes and Pipes	Sleepers	Tyres, Axles
1885	170	100	45	30	—	210	—	25	10
1890	195	145	60	25	—	120	—	25	—
1900	490	155	170	30	—	130	—	40	40
1905	820	285	285	540	—	355	—	145	50
1910	1,045	515	345	485	—	775	—	160	70
1913	1,715	500	630	700	462	860	306	190	110
1922	508	240	260	100	165	175	—	—	—
1925	605	410	420	110	340	—	240	—	—
1929	1,440	245	730	470	450	430	365	145	65
1930	1,314	207	545	390	306	220	275	95	60

Year	Rails	Merchant Iron and Steel	Blooms, Ingots, Bars	Plates and Sheets	Pig Iron	Rolled Wire	Structural Iron and Steel
1885	9	9	—	—	—	—	—
1890	45	45	—	—	170	—	—
1900	12	26	—	—	110	—	—
1910	55	222	—	9	120	—	—
1913	75	310	310	15	110	—	—
1921	133	—	605	20	670	—	31
1925	240	—	2,005	180	720	110	—
1930	330	—	2,064	162	537	164	231

BELGIUM (000 TONS)

Year	Bars, Shapes, Angles	Rails	Plates and Sheets	Scrap	Ingots, Blooms, Billets	Wire and Rods
1885	265	70	30	—	—	
1890	290	90	47	10	—	—
1900	190	75	65	42	—	—
1905	465	135	120	55	20	
1910	535	165	150	125	100	—
1913	655	165	200	—	150	54
1920	120	50	420	—	38	48
1925	1,430	170	275		675	312
1930	1,710	148	547	—	394	

U.S.A. (000 TONS)

Year	Rails	Sheets and Plates	Structural Iron and Steel	Tubes and Fittings	Wire and Fencing	Bars
1895	15	—	—		—	
1900	360	55	60	—	80	95
1905	295	75	55	120	140	50
1910	350	275	150	175	190	125
1913	470	600	370	285	93	255
1920	—	—	—			
1925	150	395	170	290	110	120
1930	95	390	244	181	80	89

CHANGES IN EXPORTS

(a) *Britain*

TABLE 113

BRITISH EXPORTS IN ORDER OF IMPORTANCE

1904	*1913*	*1929*
Pig Iron	Pig Iron	Galvanized Sheets
Plates and Sheets	Galvanized Sheets	Tinplates
Rails	Rails	Pig Iron
Tin and Black Plates	Tinplates	Rails
Merchant Iron	Steel Bars, Rods, Angles	Steel Bars
Blooms and Billets	Cast Tubes, Pipes and Fittings	Wrought Tubes and Fittings
Wire Nails and Rods	Ferro-Alloys	Plates and Sheets less than one-eighth inch
	Wrought Tubes, Pipes and Fittings	Plates and Sheets greater than one-eighth inch
	Iron Bars	Cast Tubes and Fittings
	Plates and Sheets greater than one-eighth inch	

The tendencies in the change in British exports are brought out in the following table, which compares pre-1914 with the decade 1920–30.

TABLE 114

Falling	*Maintained*	*Rising*
Pig Iron	Galvanized Sheets	Tinplates
Spiegel and Ferro Alloys	Nails and Rivets	Steel Bars and Shapes
Railway Rails	Tramway Rails	Tubes and Fittings
Cast Iron Pipes		Black Sheets
Cast Iron Manufactures		Plates not greater than one-eighth inch
Girders, Beams, Joists		Wire
Wrought-Iron Bars and Manufactures		Hoops and Strips
Anchors and Chains		Bolts and Nuts
Wheels, Axles, Tyres		Blooms, Billets, Slabs

(b) *Germany*.

The order of importance of German exports as regards quantity changed as follows between 1885 and 1929:

GERMAN EXPORTS IN ORDER OF IMPORTANCE

1885	*1914*
Merchant Bars	Merchant Bars
Rails	Pig Iron
Sheets and Plates	Blooms and Billets
Sleepers	Rails
Wheels, Angles, Tyres	Plates and Sheets
	Wire and Nails

1913	*1929*
Bars and Light Sections	Bars and Sections
Pig Iron	Plates and Sheets
Ingots and Billets	Ingots and Billets
Plates and Black Sheets	Wire
Heavy Shapes	Rails
Rails	Tubes and Pipes
Wire and Wire Rods	Sleepers, Shoes, etc.

Comparing German exports in 1920–30 with those immediately before the European War, the following changes were to be observed:

Decreased	*Maintained*
Semi-products	Sheets
Girders	Wire
Rails	Tubes

(*c*) *France.*

The order of importance of French iron and steel exports was as follows in 1913 and 1929:

1913	*1929*
Semi-products	Semi-products
Pig Iron	Pig Iron
Rails	Scrap
Structural Iron and Steel	Rails
Railway Chains	Castings
	Wire Rods

(*By semi-products is meant blooms, ingots and bars.*)

(*d*) *Belgium.*

The order of importance of Belgian exports was:

1913	*1930*
Bars, Shapes, Angles	Bars, Shapes, Angles
Plates and Sheets	Plates and Sheets
Rails	Blooms and Billets
Blooms and Billets	Wire Rods
Scrap	Scrap
Wire Rods	Rails

(*e*) *U.S.A.*

The order of importance was as follows:

1913	*1929*
Plates and Sheets	Plates and Sheets
Rails	Structural Iron and Steel
Structural Iron and Steel	Pipes and Fittings
Pig Iron	Rails
Pipes and Fittings	Bars and Rods
Bars and Rods	Wire and Wire Fencing

The order of value of exports in 1929 was as follows:

Tinplate	Welded Galvanized Pipe
Galvanized Sheets	Rails
Black Sheets	Bolts
Oil Pipe Line	

and the order of markets:

North and Central America	Europe
South America	Far East

Changes in Imports

TABLE 115

UNITED KINGDOM. IMPORT COMPONENTS (000 TONS)

Year	*Blooms, Billets, Slabs*	*Sheet and Tin-plate Bars*	*Wrought Iron Bars*	*Bars, Angles, Shapes*
1913	510	345	200	130
1920	250	36	90	55
1923	430	145	140	85
1927	945	765	300	395
1930	570	536	165	400

Year	*Plates ⅛ in.*	*Scrap*	*Girders and Joists*	*Wire Rods*	*Hoop and Strips*
1913	130	120	110	95	70
1920	155	435	—	—	—
1923	75	215	60	50	10
1927	270	—	200	140	180
1930	130	—	121	90	165

The following table shows the imports of semi-finished and finished rolled products into Britain before and after the war:

TABLE 116

SOURCE OF IMPORTS INTO BRITAIN: 1911–1928
(in thousands of tons)

Imports from		*1911*	*1912*	*1913*	*1924*	*1928*
Germany	Semi-finished	461	497	615	114	143
	Finished	327	399	511	152	208
Belgium	Semi-finished	157	116	171	525	823
	Finished	220	233	298	450	737
France	Semi-finished	—	—	—	270	247
	Finished	11	14	38	50	95
U.S.A.	Semi-finished	174	236	67	—	—
	Finished	34	72	86	23	12

The changes in the order of importance of imports into the countries being compared with Britain were as follows:

TABLE 117

Country	*1913*	*1929*
France	Pig Iron	Pig Iron
	Tinplates	Blooms and Billets
	Blooms and Billets	Structural Work
	Plates and Sheets	Tinplates
	Wire Rods	Plates and Sheets
		Tubes
Belgium	Pig Iron	Pig Iron
	Blooms and Billets	Blooms and Billets
	Wire Rods	Tubes and Pipes
	Sheet Bars	Coated Plates and Sheets
	Plates and Sheets	Bars
	Tubes and Pipes	
Germany	Pig Iron and Ferro-Alloys	Sections, Bars and Hoops
	Tinplates and Galvanized Sheets	Girders and Structural Steel
	Sections, Bars and Hoops	Pig Iron and Ferro-Alloys
	Manufacture of Cast Iron	Ingots, Billets, Blooms
	Machine Parts and Castings	Rails, Plates, Shapes
	Plates and Sheets under 1mm.	Wire
U.S.A.	Pig Iron and Ferro-Alloys	Pig Iron and Ferro-Alloys
	Bar Iron	Structural Shapes
	Ingots and Steel Bars	Scrap
	Tinplates	Sheets
		Ingots and Bars
		Pipes and Fittings

The data show that the imports into France and Belgium did not change much, but those into Germany did.

MERCHANT BARS

The production of merchant bars is shown in the following table:

TABLE 118

PRODUCTION OF MERCHANT BARS (000 TONS)

Year	*Great Britain*	*Germany*	*U.S.A.*	*France*	*Belgium*
1905	—	1,900	3,500	—	500
1910	—	1,550	3,775	—	700
1913	—	1,725	3,950	950	850
1915	550	—	4,150	—	—
1920	860	—	6,130	775	—
1925	790	2,500	5,650	1,700	600
1929	923	—	—	—	—
1930	721	2,216	4,138	2,470	890

The production of bars in Britain has remained at a relatively low level, never attaining one million tons per annum during the period reviewed and comparable with that in Belgium. Before 1914 Germany produced as much as France and Belgium put together but, although in 1920–30 Germany exceeded her pre-war output, French production increased so rapidly as to surpass Germany before the end of the period. The U.S.A. produced roughly twice the German output.

Structural Shapes

A comparison of production in the various countries is difficult owing to differences in classification—e.g., whether special sections are included with ordinary sections, joists and girders—but the following table gives the approximate tonnages.

TABLE 119

Production of Structural Shapes (000 tons)

Year	*Great Britain*	*Germany*	*U.S.A.*	*France*	*Belgium*
1900	—	—	830	—	175
1905	—	—	1,650	—	375
1910	—	1,750	2,250	500	400
1915	1,125	700	2,450	—	—
1920	1,325	400	3,300	250	—
1925	1,025	600	3,600	400	850
1930	1,123	752	3,512	771	615

The greatest quantity of structural shapes was made in the U.S.A. where the first steel bridge in the world was constructed in 1879, but Britain occupied a strong position in the production of these products, although prices were above the Continental figures.

Rails

The following table shows that during the seventies Britain produced the greatest tonnage of rails, with Germany occupying second place. In 1879, however, first place was gained by the U.S.A., which country has since led the world in output.

Although Britain occupied second place from 1880 to 1890, producing approximately one million tons per annum, we were subsequently surpassed by Germany and towards the end of the period under review we were challenged by France for third place.

TABLE 120

PRODUCTION OF STEEL RAILS (000 TONS)

Year	*Great Britain*	*Germany*	*U.S.A.*	*France*	*Belgium*
1880	740	500	830	300	—
1890	1,030	650	1,870	190	150
1900	—	1,040	2,480	280	140
1907	770	1,720	3,660	370	320
1912	690	1,790	3,350	540	340
1920	530	720	2,600	170	—
1925	570	940	2,780	530	170
1929	780	1,280	2,730	630	200
1930					

PLATES AND SHEETS

The production of plates and sheets in the various countries is given in the following table. Plates and sheets include boiler plates, thick plates, thin plates, galvanized sheets and tinplates.

TABLE 121

PRODUCTION OF STEEL PLATES AND SHEETS (000 TONS)

Year	*Great Britain*	*Germany*	*U.S.A.*	*France*	*Belgium*
1890	—	450	800	450	130
1900	—	825	1,750	675	150
1907	1,700	1,650	4,250	850	250
1912	2,050	2,000	5,900	1,100	400
1920	3,200	—	9,300	370	—
1925	3,050	1,800	9,800	650	1,250
1930	2,940	1,960	9,050	1,120?	800?

Plates and sheets constitute the principal line of finished steel production. The percentage of finished steel output represented by plates and sheets amounted to

1920	*1925*	*1930*
47·5	47·5	48·5

British output has not, however, been on the same scale as in the U.S.A. during the present century. Moreover, Germany was rapidly catching up this country in output before and after the European War. Britain's largest consuming industry for plates and sheets was shipbuilding. In the 1890's British ships built constituted 90 per cent of the world's output, from 1900 to 1914 60 per cent, and from 1920 to 1930 approximately 50 per cent. The proportions of U.S.A. and Germany are also affected by shipbuilding as up to

1912 the U.S.A. was the second country in shipbuilding, though subsequently Germany surpassed her.

Even before 1914 there were considerable imports of heavy plates into Britain and the production of ship and boiler plates declined. The output of sheets mainly from Continental bars was, however, maintained.

The consumption of sheets per capita in the countries under consideration has changed as follows, showing an increased consumption in the British home market.

	1913 *lb.*	*1928* *lb.*
France	16·4	20·8
Germany	27·5	28·8
Belgium and Luxembourg	28·8	39·5
Britain	23·2	68·2
U.S.A.	67·6	84·7

Galvanized Sheets

The following table shows the production of galvanized sheets in Britain and the U.S.A.:

TABLE 122

Production of Galvanized Sheets (000 tons)

Year	*Britain*	*U.S.A.*
1900	—	—
1905	—	—
1910	—	—
1913	—	835
1915	351	710
1920	460	840
1925	847	1,135
1929	840	1,420
1930	579	1,035

A large proportion of the British output, sometimes up to 85 pe cent, was exported, but between 1920 and 1930 the tonnage c imported sheet bars was as great as that of exported galvanize sheets. Some mills were attached to steel works and some were fre or independent. There was no organization of the industry an marketing methods left much to be desired.

Tinplates

The output of tinplates in Britain, U.S.A. and Germany is give in the following table:

TABLE 123

PRODUCTION OF TINPLATES (000 TONS)

Year	*Great Britain*	*U.S.A.*	*Germany*
1871	135	—	—
1878	245	—	—
1887	425	—	—
1893	—	55	—
1903	515	480	—
1913	825	823	83
1920	605	1,445	32
1925	765	1,782	91
1929	890	1,968	144
1930	814	1,763	126

The Siemens steel process was established in South Wales in 1868 and used commercially in 1875. The modern phase of the industry may be said to have started in 1880 and the output increased rapidly up to 1890, when Britain practically supplied the world. For a decade production remained constant owing to the fall in American imports following the imposition of the McKinley tariff. After 1900 production again increased rapidly up to 1913, due to the development of colonial and other markets. By 1924, however, production had passed the pre-war maximum.

In the U.S.A. production first attained appreciable magnitude in 1892, surpassing Great Britain in 1912. Between 1913 and 1924 it increased a further 71 per cent against 3 per cent in Britain and became more than double that in this country.

Production in other countries was of a small order; e.g. in Germany less than a tenth of that in Britain before 1914 and about an eighth in 1927, and in France even less.

The greater part (60 per cent) of British tinplate was exported to canning industries abroad. There was an agreement with the American industry on the basis of 70 : 30 in foreign markets. Whilst about 25 per cent of the tinplate bars were imported it was not relatively as large a proportion as for sheet bars, most of the tinplate mills being connected with steel works.

WIRE RODS

The production of wire rods in the five countries compared is given in the following table:

TABLE 124

PRODUCTION OF WIRE ROD (000 TONS)

Year	*Great Britain*	*Germany*	*U.S.A.*	*France*	*Belgium*
1900	—	425	850	—	—
1910	—	850	2,250	120	—
1915	170	700	3,050	—	—
1920	260	500	3,150	140	—
1925	200	950	2,850	420	260
1930	233	863	2,350	354	272

From 1890 onwards the U.S.A. has produced far and away the greatest quantity of wire rods. German production increased steadily up to 1913 and occupied the second place in the world order, which it retained after recovery from the effects of the European War.

From 1925 to 1930 France was the third producer and British output was comparable only with that of Belgium. The low position of Britain in this trade was due to inability to compete with Continental rolled Bessemer steel, wire drawing being mainly carried out in the Manchester and Birmingham areas from imported wire rods.

TUBES

The production of tubes in Britain was not important enough to be recorded as a separate item in the statistics of the N.F.I.S.M. The output was considerably less than in Germany and about equal to that of France. Scotland, South Wales and Midlands were the areas engaged in tube drawing.

There were few firms engaged in tube production, which was largely from imported strip. Exports were a considerable proportion of production but often to British engineering firms working abroad. There was an international cartel in tubes to which the British Tube Association belonged.

WAGES

TABLE 125

PERCENTAGE COST OF WAGES

German Data (1896)

	Cost per ton Marks	*Wages Marks*	*Per cent*
Pig Iron	47·3	2·9	5·3
Steel Ingots	62·0	2·2	3·5
Steel Rails	90·7	5·5	6·1

TABLE 125—*continued*

U.S.A. Data (War Time Profits and Costs, 191[illegible]

	Cost per ton $	*Labour* $	*Per cent*
Ingots, Open-hearth Furnace	33·22	1·43	4·[illegible]
Ingots, Bessemer	29·80	0·97	[illegible]·3
Billets at Mill	40·61	1·13	2·[illegible]
Heavy Rails, Open-hearth	39·77	1·94	[illegible]·[illegible]
Heavy Rails, Bessemer	48·89	2·47	5·0
Shear Plates at Mill	55·50	3·65	6·6
Universal Plates	44·98	2·54	5·6
Structural Shapes	49·22	3·08	6·[illegible]
Merchant Bars	50·63	4·30	8·5
Wire Rods	50·76	2·37	4·7
Tinplates from Bars	5·87	0·33	5·6

British Data (Census of Production, 1930

		Per cent	
	Materials	*Labour*	*Other Costs*
Pig Iron	84	15	1
Steel Melting	71	21	8
Rolled Products	73	21	6
Galvanized Sheets	73	20	7
Tinplates	68	23	9
Tubes	57	23	20
Wire	69	19	12
Industry as a whole	59	30	11
(47 materials)			
(12 transport)			

WAGES IN STEEL WORKS IN 1926 (U.S.A. Bureau of Labour)

	Great Britain (max.)	*U.S.A.*	*Germany (max.)*
BESSEMER CONVERTERS			
Blowers	—	45/5	12/-
Labourers	—	14/8	6/8
Regulators	—	31/7	12/5
OPEN-HEARTH FURNACES			
Melters	37/6	39/-	11/5
Pourers	17/5	29/8	—
Labourers	6/10	14/4	—
PUDDLING MILLS			
Puddlers	16/-	25/7	—
Puddlers' Helpers	9/7	21/8	—
ROLLING MILLS (BARS)			
Heaters	18/3	31/7 to 39/9	19/-
Rollers	23/-	56/10 to 71/-	23/-
Roughers	11/2	28/3	—
Labourers	6/9 to 7/9	13/4	8/7

TABLE 125—*continued*

	Great Britain (max.)	U.S.A.	Germany (max.)
Blooming Mill			
Roller	—	62/6	16/7
Shearman	—	33/10	13/–
Labourer	—	18/9	9/5
Plate Mill			
Roller	—	56/10	15/5
Shearman	—	36/10	12/4
Tinplate Mills			
Rollers	23/–	54/9	—
Doublers	18/9	26/3	—
Shearers	22/2	34/–	—
Turners	16/9	28/–	—
Assorters	20/2	12/8	—
Labourers	—	14/4	—

The following table of shift wages in Britain and Germany illustrates the recovery of German wages after 1924, when real wages became higher than before the war.

TABLE 126

Shift Wages

Year	British	Westphalian
1913	7/1	5/11
1920	18/3	—
1922	10/3	2/–
1924	11/4	6/11
1925	11/7	8/5
1926	10/9	8/9
1927	11/4	9/8
1928	10/6	10/–
1929	11/9	11/2

On the other hand, British real wages were lower.

Comparative Purchasing Power of Engineering Wages

	1913		1926	
	Skilled	Unskilled	Skilled	Unskilled
U.S.A.	141·4	133·5	175·4	125·7
Britain	100·0	100·0	100·0	100·0
Germany	71·4	84·0	78·8	89·5
France	70·0	76·3	91·7	86·3
Belgium	68·1	77·6	78·8	89·5

The fall of wages in Germany prior to 1924 did not cause the inefficiency which might be anticipated as price control of the cost of living was exercised by the State.

The following table shows the average wage in steel works in 1930:

		Britain	Germany	France	Belgium
Skilled	Melting	175/4	68/6	51/6	53/9
	Rolling	114/10	—	—	—
Semi-skilled	Melting	96/4	—	—	—
	Rolling	71/-	52/10	40/3	38/10
Labourers	Melting	51/2	—	—	—
	Rolling	45/9	47/-	32/2	30/10
Average, all classes		66/6	50/11	37/-	35/3

Railway Rates

In 1880 railway rates per ton-mile on some products are given below for foreign iron-producing countries.

Railway Rates per Ton-Mile in 1880 (Pence)

	Coal and Coke	Iron Ore	Pig Iron Export	Pig Iron Home	Manufactured Iron Export	Manufactured Iron Home
Belgium	0·74	0·56	0·63	0·88	0·63	0·88
France	0·85	0·66	0·78		0·84	
Germany	1·46	0·51	0·66		0·72	
Luxembourg	—	0·46	—		—	
U.S.A.	0·55	0·56	0·70		0·70	

Whilst freight rates in Britain at that date are not ascertainable it is probable that they were 30 to 50 per cent higher, as indicated by the detailed information four years later, given in Table 127.

TABLE 127

RAILWAY RATES PER TON-MILE (PENCE)

HOME AND FOREIGN IRON AND STEEL INDUSTRIES, 1884

Great Britain		*U.S.A.*		*Germany*		*France*		*Belgium*	
IRON ORE	*Average*		*Average*		*Average*		*Average*		*Average*
N. Staffs	0·73 0·51–1·6	Philadelphia and Reading Railway	0·49	Port to Works	0·42	Inland Towns to Inland Towns	0·66	From Luxembourg	0·40
Lancs	1·2–3					Ports to Works	0·53–0·57		
Cleveland	1·0–0·75	Goods and Minerals	0·61			Nord	0·88		
W. of Scotland	1·79								
Northampton	0·55								
COAL AND COKE				In Rhenish Provinces, plus a small booking charge	0·42	From St. Etienne Valenciennes, Lens, etc.	0·88	Home consumption	0·64
S. Wales	0·82								
Lincs	0·62								
PIG IRON				From Westphalia	0·50	Works to Ports	0·59		
To ports from Lancs				Works to Ports	0·58				
146 miles	0·87								
126 miles	0·97								
N. Staffs	0·73								
S. Wales	0·73								
W. Cumberland									
127 miles	0·77								
162 miles	0·65								
Northants	0·98								
Cleveland	0·77								
Average	0·83								

Inland rates	
Barrow	0·86
Staffs	
S. Wales	0·85
Cleveland	0·86
W. Cumberland	0·76
Northants	1·02
To Sheffield	0·73
Port to Inland	1·12
Average	0·94

		Inland delivery	0·60		

MANUFACTURED IRON	
To Ports from:	
S. Wales	1·00
W. Cumberland	1·16
Cleveland	0·80
N. Staffs	1·01
S. Staffs	1·37
Average	1·06
Inland rates:	
S. Wales	·1·11
W. Cumberland	1·12
Lancashire	1·63
Cleveland	1·26
N. Staffs	1·95
Average	1·41

Westphalia to Shipping Ports:		Works to Ports	0·59	Export	0·86
Hamburg	0·50				
Bremen	0·55				
Antwerp	0·52				
Silesia	0·69				
Works to Hamburg:					
Stettin	0·53–0·54				
Inland delivery	0·67	Works to Inland Towns	0·59–0·66	Home Consumption	0·86–1·11
	0·67		0·66		1·11

Appendix to Chapter VII

British Associations in 1917

Thirty-five Employers' Associations were reporting to the Departmental Committee of the Board of Trade in 1917.

1. Cleveland Iron Masters' Association.—From 1904 to 1914 produced 37 per cent of total output. Native ironstone decreasing. Getting more dependent on imported ores. Suffered from high charges for surface damage and high (traffic) railway rates
2. West Coast Iron Committee (formed at the request of the Ministry of Munitions).—1913 production 1,003,650 tons, value £4,160,000. Home consumption, 992,000 tons. Capital, £1,690,000. 35,700 tons hematite ore imported. Iron royalties high, 1/– to 5/– on fixed basis, but on sliding scale 10/– to 15/–.
3. Scottish Iron Masters' Association.—In 1913 591,500 tons of ore were mined and 1,820,000 tons imported from Spain, Norway and Sweden. Average production of pig iron, 1,355,000 tons 1904–13. No increase. Cost of production had risen. Scottish furnaces were coal fired.
4. South Staffordshire Iron-Masters' Association.—Capital of associated firms, £4,000,000. Re-rolling firms depended upon Continental steel billets. Export trade done through export merchants.
5. Association of Ferro-Manganese and Spiegeleisen Manufacturers.—Capital of associated firms, £1,250,000. Manganese ores came from India, Caucasus, Brazil, South Spain.
6. British Rail Makers' Association.
7. Tram Rails.—Average output 1902–5, 60,000 tons; 1910–13, 29,000 tons. Imports 1907, 3,800 tons; 1913, 10,000 tons.
8. British Joist Makers' Association.—Production 1913, 282,000 tons; exports, 93,000 tons. Exports and imports approximately equal. Proportion of ingot steel rolled into joists: Great Britain, 3·7 per cent; Belgium, 7·1 per cent, Germany, 8·2 per cent.
9. North-East Coast Steel Makers' Association (formed 1897).—Special arrangements between the makers and British shipyards as regards plates and angles. Lack of selling co-operation lead to uneconomical methods.
10. Midland Steel Angle Makers' Association.—Supply rolling stock builders, bridge and constructional works. Considerable quantities of blooms, billets and bars are imported.

11. Scottish Steel Makers' Association.—Capital, £3,500,000. Number of men, 12,500. Average output 1912–13, 873,900 tons; value £6,638,000. Manufacturing co-operation practically non-existent. Central Selling Agency needed, especially for export.

12. Small Steel Bar Association (Midlands).—Output, 200,000 tons per annum at £7 per ton. Total output for country 800,000 tons. 1912 and 1913 billets used 113,000 tons home, 128,000 tons abroad.

13. South Wales Siemens Steel Association.—Practically ruined by McKinley Tariff, 1890. 15 steel works (1917) capacity, 1,500,000 tons. 1913 imports blooms, billets, slabs, etc., 860,000 tons at dumped prices.

14. North-East Coast Bar Makers' Association.—Capital, £35,000 Number of men, 1,960. Bulk of trade in iron, but of steel billets used 87 per cent imported from Continent. British common iron ousted from India, Africa, Japan and South America.

15 Lancashire Bar Manufacturers' Association (includes Derby and Yorks).—Output, merchant bars 260,000, merchant hoops 100,000 tons. Half exported. Soft steel billets are largely imported. Loss of Argentine trade attributed to freight rates. Antwerp to Buenos Ayres 35/–, Liverpool 50/–.

16. South Yorkshire Bar Iron Association.—Capital, £750,000. Output, 160,000 tons. Mechanical puddling.

17. Scottish Bar Iron Manufacturers' Association.—Scottish production malleable iron, 300,000 tons; 40,000 tons exported; 73,000 tons imported; steel billets also rolled. Capital, £1,400,000.

18. Welsh Plate and Sheet Manufacturers' Association.—Capital over £6,000,000. Men employed, 26,500. Wages, £2,500,000 1913; 170,000 home market, exports 566,000 tons. Value, £8,000,000.

19. Sheet Makers' Conference consumes 1,000,000 tons steel, 100,000 spelter annually (galvanized sheets). Persons employed, 20,000. Wages, £3,000,000, 1913; 31 per cent or 340,000 tons of steel bars imported and the spelter. 1913 exports 962,000 tons, value £10,028,000. Home less than one-tenth.

20. The Federated Forge Masters.—Capital, £40,000,000 of which £5,250,000, engaged in forging. 1913, 26,782 tons of marine forgings. Total capacity, 240,000 tons of forgings all descriptions.

21. English and Scottish Forge Masters' Association.—Marine shafts and forgings for engines and turbines. Total capital, £5,026,000. Forging departments, £45,000. 1913 output, 12,000 tons, value £339,000.

22. Midland Forge Masters' Association.—Capital, £711,000, 1913 output 25,488 tons.

23. Steel Castings Manufacturers' Association.—Total capital, £21,285,000, of which £2,688,000 in castings departments. Output 1913, 97,448 tons, value £2,500,000; 90 per cent for home market.

24. National Light Castings Association.—1913, output value £5,000,000; 25 per cent exported. Suffers from restriction of output. Wage costs higher than in U.S.A.

25. Scottish Employers' Federation of Iron and Steel Founders.—Heavy castings. Capital, £2,000,000. Output 1913, 325,000 tons, value £3,250,000.

26. Cast Iron Pipe Founders' Association.—Output of pipe foundries 510,000 tons, 220,000 tons exports. Capital, £2,150,000. Employees, 13,800. Wages, £1,150,000. Output, £4,000,000. Skilled representatives maintained abroad.

27. Cast Iron Hollow-Ware Makers' Association.—Foreign competition not largely felt at home.

28. Iron and Steel Wire Manufacturers' Association.—Until 1880 supplied the world. 1913 output, 200,000 tons. Germany, 1,000,000 tons. U.S.A. exports more than 200,000 tons. Prior to 1900 British steel only used; 1913 and 1914, 100,000 tons wire rod imported per annum and nearly 500,000 tons of billets.

29. Wire Netting Manufacturers' Association.—Output before war 35,000 tons, value £700,000. Imported 17,000 tons wire in 1913.

30. Steel Nail Manufacturers' Association.—Cut nail trade 35,000 tons in 1899-1903. Wire nails 24,000 tons in 1913.

31. Rod Rollers' Association.—Capital, £450,000. Yearly output about 115,000 tons wire rods; 1913, 100,000 tons wire rods imported.

32. British Tube Makers' Association.—Capital, £3,972,000. Output value, £5,500,000. Twenty per cent of the iron and steel imported. High railway and shipping rates.

33. Weldless Steel Tube Association.—Capital, 1913, £1,150,000. Output, 36,000 tons. Value, £1,000,000. Imported billets or rolled tubes from Sweden 16,000 tons.

34. Railway Tyre and Axle Makers' Association.—Tyres and axles 1913, value £2,300,000. Home, £958,000. Dominions, £1,009,000. Wheels and axles, £1,750,000. Home, £392,000. Capital, £2,100,000 plus £1,021,500.

35. Bridge and Constructional Ironworks Association.—500,000 tons of steel used per year. Two-thirds goes abroad.

36. Enamelled Pressed Hollow-Ware.—Output 1913, 7,000 tons, £50 per ton. German and Austrian exports to British Empire, 12,000 tons.

TABLE 128

Associations in the British Iron and Steel Industry Engaged in Regulating Prices and Output (1919)

Trade	*Association*	*No. of Members*
Pig Iron	Cleveland Ironmasters' Association	17
	Scottish Ironmasters' Association	12
	South Staffordshire Ironmasters' Association	—
	West Coast Iron Committee	7
	Ferro-Manganese and Spiegel Association	5

TABLE 128—*continued*

Trade	*Association*	*No. of Members*
rought Iron	English and Scottish Forge Masters' Association	18
	Federated Forge Masters	13
	Midland Forge Masters' Association	—
	Lancashire Bar Iron Association	—
	Scottish Bar Iron Makers' Association	13
	South Yorkshire Bar Iron Association	10
	North-East Coast Bar Iron Association	5
ast Iron	Cast Iron Hollow-Ware Makers' Association	—
	British Cast Iron Pipe Founders' Association	—
	National Light Castings Association	—
teel	Scottish Steel Makers' Association	—
	North-East Coast Steel Makers' Association	10
	South Wales Siemens Steel Association	8
	The Ingot Makers' Association	—
teel Castings	Steel Castings Manufacturers' Association	20
Rolled Products	British Joist Makers' Association	9
	British Rail Makers' Association	16
	Billet Makers' Association	—
	Midland Steel Angle Makers' Association	6
	Small Steel Bar Association	8
	Sheet Makers' Conference	31
	Welsh Plate and Sheet Makers' Association	—
	Rod Rollers' Association	11
Miscellaneous	Bedstead Makers' Federation	—
	Iron and Steel Wire Manufacturers' Association	29
	Midland Bolt and Nut Manufacturers' Association	30
	Lancashire and Yorkshire Bolt and Nut Makers' Association	25
	Cut Nails Association	—
	Tube Makers' Association	32
	Weldless Steel Tube Makers' Association	7
	Wire Netting Association	10
	Railway Tyre and Axle Makers' Association	14
	Railway Wheel and Axle Makers' Association	15
	Steel Rope Wire Makers' Association	—
	Coil Spring Makers' Association	—

NOTE.—In 1922 most had ceased to function, but in 1923 many were revived by trade recovery. In most branches foreign competition made price control nominal.

TABLE 129

EMPLOYERS' ASSOCIATIONS IN THE IRON AND STEEL TRADES.

MEMBERS OF THE FEDERATION OF BRITISH INDUSTRIES, 1927

Heavy Production

Lincolnshire Ironmasters' Association.
Iron and Steel Trade Employers' Federation.
British Joist Makers' Association.
Sheet Makers' Association.
Lancashire Bar Manufacturers' Association.
Scottish Steel Makers' Association.
North-East Coast Steel Makers' Association.
South Wales Siemens Steel Association.
British Wire Rod Rollers' Association.

Medium

Railway Wheel, Axle Manufacturers' Association.
Railway Carriage and Wagon Builders and Financiers' Parliamentary Association.
Steel Castings Manufacturers' Association.
National Light Castings Association.

Finishing

Steel Rail Association.
Association of British Steel Penmakers.
Shoe Rivet Manufacturers' Association.
Pin, Hook and Eye and Snap Fasteners Employers' Federation.
Redditch and District Needle and Fishing Tackle Employers' Association.

TABLE 130

GROUPED FIRMS IN BELGIUM PRIOR TO 1914

The following was a list of works affiliated to the Groupement des Hauts Fourneaux et Acieries Belges before the war:

S.A. d'Ougrée-Marihaye à Ougrée.
,, John Cockerill à Seraing.
,, des Forges de la Providence à Marchienne-au-Pont.
,, de Sambre et Moselle à Montigny-sur-Sambre.
,, des Acieries d'Angleur à Tilleur.
,, des Usines Metallurgiques du Hainaut à Couillet.
,, des Usines de Thy-le-Chateau et Marcinelle à Marcinelle.
,, d'Athus-Grivegnée à Grivegnée.
,, Metallurgique d'Espérance-Longdoz à Liège.
,, des Forges de et à Clabecq.
,, Usines de Moncheret à Acoz.
,, des Usines Bonehill à Houpes-Thuin.
,, des Hauts Fourneaux et Mines de et à Halanzy.
Les Usines Gustave Boel à la Louvière.

TABLE 130—*continued*

The following was a list of works affiliated to the Comptoir des Aciéries Belges:

S A. d'Ougrée-Marihaye à Ougrée.
,, John Cockerill à Seraing.
,, des Forges de la Providence à Marchienne-au-Pont.
,, de Sambre et Moselle à Montignies-sur-Sambre.
,, des Aciéries d'Angleur à Tilleur.
,, des Usines Metallurgiques de Hainaut à Couillet
,, de Thy-le-Chateau et Marcinelle à Marcinelle.
,, d'Athus-Grivegnée à Grivegnée.
,, d'Esperance-Longdoz à Liège.
,, des Forges de Clabecq à Clabecq.
,, d'Alliance-Monceau à Monceau-sur-Sambre.
Les Usines Gustave Boel à la Louvière.

TABLE 131

Hours of Labour in Britain

(Board of Trade.)

	1906		*1924*			*1929*	
	Average Hours	*Per cent Working 48–56 hours*	*Average Hours*	*Per cent Working 48–56 hours*	*Shift Hours*	*Average Hours*	*Shift Hours*
Blast Furnaces	55·2	80·8	53	97·8	56	53	46·6
Steel Works	54·4	49·1	41·8	1·8	42·3–47·6	41·8	46·7
Rolling Mills	41	11	—	—	42–45	41·8	46·7
Tinplate	47·8	41·9	40·0	—	—	40·6	46·8

Hours of Labour in Germany

Weekly hours worked in the Ruhr were as follows:

1913	54·6	1926	—
1923	48·0	1927	54–52
1924	57·5	1928	52·0
1925	56·0		

Hours in October 1928	*Blast Furnaces*	*Steel Works*	*Rolling Mills*
Founders or rollers on piece	53½	50¼	48¾
First founder or roller	54	51¼	49¾
Second founder or roller	53¼	49¾	48½
Third founder or roller	53¼	49½	48¼
Other workers on piece	56¼	50½	50¾
Other workers hourly	57¾	51¾	53
1929	53¼–57¾	49½–51¼	48¼–50¾
1930	56	48	48

TABLE 131—*continued*

HOURS OF LABOUR IN THE U.S.A.

	Bessemer Plant	*Blast Furnace*	*Whole Industry*
1913	70 72	76·9	66·1
1914	68 4	74·8	64·9
1915	68·7	74·9	65·5
1920	70 3	72·1	63·1
1922	68·7	72·5	63·2
1924	52·3	59·3	55·2
1926	52·6	69·8	54·4
1928	—	62·0	—
1929	53·7	60·7	54·0

	1922	*1924*	*1926*	*1929*
Skilled men	54·1	49·9	50·1	50·3
Semi-skilled	64·2	55·0	54·3	53 9
Labouring	66·4	59·9	58·8	60·0

PERCENTAGE OF WORKERS WITH OVER 60-HOUR WEEK

	1922	*1926*
Blast Furnace	79	24
Bessemer Converters	76	9
Open Hearth	78	17
Puddling Mills	18	4
Blooming Mills	68	14
Plate Mills	60	18
Rail Mills	53	13
Bar Mills	66	6
Sheet Mills	22	4
Tinplate Mills	15	2

FULL-TIME HOURS PER WEEK

	1922	*1929*	*Reduction %*
Blast Furnaces	72·3	60·7	16
Open Hearth	70·8	57·7	18
Bessemer Converters	68·7	53·7	22
Bar Mills	61·2	55·6	9
Rail Mills	61·5	56·9	7·5
Sheet Mills	51·1	48·9	4·3
Tinplate Mills	49·9	47·4	5
Puddling Mills	52·1	50·3	3·5
Blooming Mills	68·0	55·0	4·3
Plate Mills	66·2	58·0	12·4

In 1929 26·9 per cent of employees were said still to be on a 7-day week.

APPENDIX VIII

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d. = diagram. *t.* = table.